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EDITOR'S OUTLOOK

Since practically each state or group of states has an association of chemistry teachers and since it is difficult to get together during the school year, would it not be well to have a big meeting either just after the close of schools and colleges in June, or just before the opening dates in September? This large meeting might take the form of a symposium in each state or group of states lasting perhaps one week where the forenoons could be given over to papers and discussions while the afternoons might be spent in excursions, games, etc., that is, if the locations were favorable such symposiums might take the form of partial vacations. Almost any college or university, where chemistry is "a live issue," would undoubtedly make an attractive invitation through their dormitory accommodations, etc.

The following are ten of the many topics which are suggested for discussion:

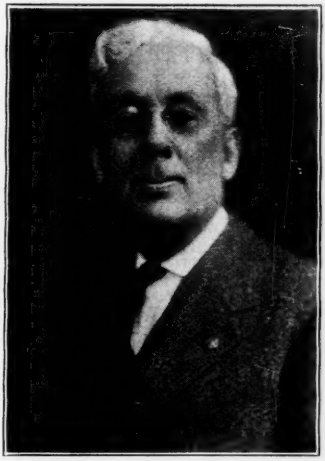
1. Opportunities presented by the Prize Essay of the A. C. S.
2. Guiding principles in developing interest in chemistry
3. The necessity of higher chemical standards in teaching high school chemistry
4. How a chemistry department may be well equipped with very moderate means
5. Important features about the building of chemical departments and chemical buildings
6. The development of character through chemistry
7. An ideal chemistry class in action
8. How to build up a chemical library
9. Better pay for chemistry teachers
10. Objectives in high school and college chemistry.

Dr. J. F. King, of Williams College, was the first to suggest a symposium of this nature. If there are others who are making like plans, let us know at once so that the notices may be placed in the next issue of THIS JOURNAL.

THE AMERICAN CHEMICAL SOCIETY AND EDUCATION

JAMES F. NORRIS, PRESIDENT AMERICAN CHEMICAL SOCIETY, NATIONAL RESEARCH COUNCIL, WASHINGTON, D. C.

The formation of the Division of Chemical Education of the American Chemical Society will, no doubt, lead teachers of chemistry to become more interested in real education. Much of the instruction given in colleges follows the individual methods handed down by our former teachers. The modern point of view in regard to education and the highly complex art of teaching are not adequately considered because the only requirement ordinarily put upon the prospective teacher is a knowledge of facts. This condition can be changed if more attention is given to the study of the many problems of education before the teacher, who oftentimes is blind to them. The focusing of interest on these problems by the Division of Education cannot but eventually affect favorably the teaching of the science. The day is bound to come when outstanding success in teaching will receive as much recognition as is awarded today to accomplishment in administration or research.



DR. JAMES F. NORRIS

In the past the American Chemical Society has given some attention to educational topics. Certain Divisions of the Society have had very profitable discussions of various phases of the teaching of chemistry, but the interest has been more or less spasmodic.

Increased attention to educational problems finally led to the formation of the Division of Chemical Education. There has been need for such a Division for a long time. Many members of the Society are teachers and their chief interest lies in the field of education. Their work is as important as that of the chemist who is applying his knowledge in other ways.

The more thoughtful teachers are using the methods of research in studying the problems before them, and the formation of the Division of Chemical Education offers the opportunity to present their results to their fellow teachers. It is as important to inspire and report progress in educational research as in any specific field of chemistry.

The foresight of those who brought about the establishment of the Division and who have planned its activities will result in bringing together the college teacher of chemistry and his colleague in the preparatory school. The coöperation which will follow will mean much to both. The college

teacher has for his raw material the product of the secondary school, and it is as true in education as it is in industry that the chemist must have an intimate knowledge of his raw material. Both must know the properties of their materials and the conditions under which they are prepared. Both must use every effort to obtain as high grade material as possible, but unreasonable requirements must not be set up in either case.

It is of great importance for the college teacher to become better acquainted with the educational problems involved in the teaching of science in secondary schools. He should learn what conclusions have been reached by thoughtful teachers in the high schools in regard to the proper course in chemistry to be given to their pupils. He should appreciate that the problem in secondary education is quite different from his own, and he should not set up standards for entrance to college which are inconsistent with the best educational policy as applied to the many who study chemistry in the high school only.

The college teachers of the more specialized branches of chemistry will, through the Division of Chemical Education, have an opportunity to consider the particular methods of instruction best adapted to their own subjects. No one is willing to say that we have found the best way to teach analytical, organic, or any other division of chemistry.

The teacher in the secondary school should find the Division of great value to him. Here he can get the point of view of the college, can state his case, and can develop himself in his profession. Membership in the American Chemical Society will bring him into association with the men who are making his science take a foremost place in the educational and material development of the world. Contacts of the greatest value can be developed through the meetings of the local Sections of the Society, and opportunity furnished to keep in touch with the latest developments in the science.

Whenever the live teacher of chemistry in the secondary schools has taken an interest in the affairs of the local Section, his influence has been felt. One progressive Section of the Society devotes a meeting each year to the consideration of subjects of particular interest to college students. Why should not the high school student be favored in the same way?

The program of one of the most inspiring meetings of the Northeastern Section of the American Chemical Society, held last year, was planned to interest high school students. The subject considered was the chemical activities of the commonwealth—what is being done to guard the health of its citizens, to improve agriculture, and to advance the general welfare were described in a simple but convincing manner. The prize winners in the American Chemical Society Prize Essay Contest were invited to attend and those present were separately presented to the audience. The meeting was an inspiration; its success suggests the possibility of the de-

velopment of the influence of our local Sections in bringing the story of chemistry to the attention of the public. In such work the coöperation of the high school teachers will be of the greatest value.

THE JOURNAL OF CHEMICAL EDUCATION will hold first place in awakening and developing an interest in the important problems before the teacher. It will serve as a forum for free discussion, and the means of broadcasting the results of experimental researches in teaching as applied to chemistry. A chemist who is doing research work in chemistry must have the *Journal of the American Chemical Society* on his desk. It is one of his tools. One need not be much of a prophet to foresee the day when the teacher of chemistry who looks upon teaching as a highly technical profession will take a similar attitude toward his journals devoted to the art and science of education.

THE LABORATORY STUDY OF CHEMISTRY

HERBERT R. SMITH, LAKE VIEW HIGH SCHOOL, CHICAGO, ILL.

If facilities for individual laboratory work in chemistry or any other science can be provided it is generally accepted by school administrators and the public as well, that excellent work will be done by the pupils. It is true that the possibilities are there, but numerous conditions must be taken into account that vitally affect the final results. Facilities are important but they are far from being the most important factors in teaching.

The writer firmly believes in the laboratory method of teaching, but he has found that the laboratory work of many pupils bring little result for the expenditure of time and materials; and nearly as large a fraction of the pupils not only receive little value but are positively confused by the laboratory procedure. Procedures that were generally successful 20 years ago no longer bring similar results now. They are successful with the upper fourth of high-school pupils which fairly represents the quality of the whole high-school enrolment of 20 years ago. Laboratory methods have been improved little in the past two decades. The equipment of our schools has been wonderfully improved but the procedure and the spirit in which it is attempted have not been proportionately improved. Several types of laboratory instruction will be characterized.

The *illustrative* type, individual and general, is unquestionably the most in vogue at present. The laboratory work furnishes an example of what has been stated in the textbook or by the teacher. It usually implies that a verification of these statements is expected or demanded by the pupil. However exacting the pupil may be wherever this procedure is followed, plenty of cases may be found where the pupil is obligingly recording the facts of the experiment, not as they are being made manifest in the ex-

periment under way; but as he is finding them stated in the textbook. For such reasons as these the writer long ago excluded the textbook from the laboratory, at least while experimentation was under way.

Too many pupils will yield to the temptation to let the textbook do their thinking. Here is the chief objection to the average text. It furnishes ready formed the information that the experiment is expected to present. Instead of training in the interpretation of phenomena and thinking to conclusions, the pupil has only a copying exercise. Many laboratory manuals actually call for the use of the text in connection with the laboratory work. The writer holds that no question should be put to a pupil in the course of the experiment, that cannot be reasonably answered by the data of the experiment. Questions requiring reference work should not distract the pupil's attention from the experiment but should be incorporated in following lessons. It is well known that to allow the use of the text in the laboratory saves the labor of answering many questions, the pupils do not have to repeat experiments, and the written records of them require little or no correction. As a means of self-satisfaction it is equal to the method said to be used by the ostrich in concealing himself by hiding his head in the sand.

At this point some pertinent questions are asked of all science teachers. Why is it that in our thoughtful moments we admit that mental training is far more important to the pupil than acquired information, yet everywhere we put the emphasis on the information in the textbook, the syllabus, the examination, and the experiment, and let the pupil find his own way of obtaining it? Shall we not as teachers rather show the pupil *how* to collect and assimilate information, and not merely assign lessons and let him find, if he can, the *how* of it? If we have trained the pupil in the art of acquiring information, then if he lacks knowledge will he not have the power to remedy the situation at any time? But if he has not the art of learning, then with all that we have been able to cram into his cranium will he not be poorly equipped to solve the problems of life?

Another phase of the illustrative type of laboratory method is much more favorable since it is entirely under the teacher's control and even with inexperienced teachers is not far from satisfactory. This is commonly called the teacher-demonstration plan. Its common use is easily justified by reason of the economy of time, materials, and the nature of the topic. At the Lake View High School it has been modified by having the pupils take a more active part. It may be styled the teacher-pupil demonstration. After a working hypothesis is established as an introduction the class is gathered about a laboratory table with two pupils conducting the experiment. The remainder of the class watch and think under the direction of the teacher *who gives his whole time to instructing.* He sees to it that every significant fact is seen and its relation to others understood. The doubt-

ful pupil is questioned, a part of the experiment may be repeated, and further explanation given *when and where needed*, without loss of time and laborious corrections of mistakes. The best time to correct a mistake is just before it is made. Each pupil writes a final record of the experiment while the facts are before him. The instructor knows for a certainty that each pupil has thought through the procedure to the final conclusions. He knows that training has been given to the pupil for he has been a witness of the act. The time to accomplish this definite work is one-half to two-thirds of that required when the pupils each work separately at the task, and in most cases do little thinking during the process. There is a saving of at least nine-tenths of the material and apparatus. For these reasons this method is admirably suited to the small school having limited equipment. No teacher need feel that he is seriously handicapped by limited materials in the teaching of chemistry. Many schools are doing less for their pupils by having too much equipment.

The question of retention of information obtained by the shorter experimental time may be raised against this plan. Such objection is apparent only and not real when other facts are considered. The shorter time for absorption is more than offset by clearer and more definite conceptions obtained, and particularly by the fact that all experimental data are built up into one large unit of knowledge with related parts. In addition, time is saved for later drill and review. A point that should appeal to teachers is that the records written under this plan are correct when finished and as the pupils complete their part the teacher's work is finished except for the entering of credit for the work done. Teachers who are burdened by the correcting of note books and experimental records are performing the work of drudges and not instructors.

It has been said that pupils who do the poorest work in the laboratory are the ones who should have the most of it. They do poor work because they do not know how to do it. What is needed is instruction, not more confusion. The considerate use of the above method soon brings the pupil to a state of understanding such that he can direct his own efforts and learn from laboratory practice.

The laboratory method that most science instructors instinctively hold in mind may be summed up by the sentence, "The pupil experiments and finds out for himself." This condition is apparently satisfactory but the first half of the statement is the only certain accomplishment. By the individual method the pupils at Lake View are found to come far short of what might and should be expected. Of the third and fourth year pupils who enroll for chemistry only 12% obtain a reasonable return for the time used. Many seem to do the experiment satisfactorily even to making a fairly accurate record but actual tests show little acquired information and no ability to think in a simple parallel case. Consequently the method is

considered a failure except for the 12%. Further studies show that 38% are much confused in mind as to what it is all about by the individual method. It is rather a misnomer to call the method "individual" for if the teacher will permit, the written records of this group will come in, each one almost exactly like that of his neighbor. These pupils do not intend to be dishonest, they are the victims of circumstances. They have obtained passing, or good, sometimes excellent grades in other subjects where memory has served to reproduce what the teacher or textbook has said. They have acquired so far in school little ability to think. The attainments of the 38% under this method would class them as failures in knowledge if not in grade. Some schools schedule consulting periods during hours when pupils may obtain special help. Such a plan is wasteful of the instructor's time for he may as well instruct a group as one. Frequently the plan is not possible because of a crowded program. If it were possible to divide the pupils enrolling for chemistry into classes on the basis of ability the problem could be simplified. In small schools, however, this plan presents no solution if there is but one class. In the larger schools the program difficulties are so numerous that administrative officers are not inclined to add another problem to their labors.

A satisfactory solution of the problem has been found at Lake View by the use of the teacher-pupil method of laboratory work. Pupils who prove their ability to direct their own efforts are permitted to work alone. All the others are carefully trained in experimenting and thinking until such time as a sufficiently simple experiment is at hand for them to undertake alone. By this method 120 pupils proved their attainments not only in information but in ability to think as well.

There has been necessary delay in putting the plan in full operation until the teacher has sufficient acquaintance with the pupils to be able to judge their ability. During the past semester the Terman Group Test of Mental Ability was given all the pupils to see if it might not be a suitable index of the pupil's ability so that the method might be put in full and certain operation from the start. From the fact that the Terman score was a more reliable test of pupil ability than the teacher's judgment made it seem very probable that the Terman scores would be a reliable index. Careful study of pupil records with Terman scores showed that those scoring 190 or above performed nearly every experiment with profit. Those below 150 could do very few experiments with profit, and for those between these two groups, the individual scores indicated what experiments could be done with profit without direct supervision. All scores of the 120 pupils except two of foreign birth were well above the established norms for this test. Finally as many as 84 of the 120 pupils acknowledged that they had learned to study under the methods used in chemistry during the past semester.

A MINIMUM OR MAXIMUM COURSE IN CHEMISTRY

CARL WILLIAM GRAY, HOLLYWOOD HIGH SCHOOL, HOLLYWOOD, CAL.

Not many years ago high-school chemistry and physics were not taught as individual subjects, but were taught together as Natural Philosophy. At the time, but little science was offered in the colleges, and it was only the bolder leaders who experimented by putting into the high schools or academies an abbreviated college course. Unfortunately we are still teaching high-school chemistry much as it was taught when introduced. Chemistry has grown by leaps and bounds, and material has been added to the high-school course until, at present, the student finds an overwhelming mass of facts. In this rapidly growing subject there has not been sufficient time for the teacher to properly consider the motley assortment of information to see if dead timber is being carried, and if so, to throw it over-board. Dead timber is hardly the right word because none of this material is dead; it is only of less importance, and we do not have time to present it.

How much time have we to cover a year's chemistry course? In a school year we cannot count the first week of school because the classes are still unsettled. This is true, at least, in the Middle West and on the Pacific Coast where high-school attendance often increases enormously in a short time, a condition which brings up administrative problems that could not be foreseen. The last week of school is also broken up and usually given over to final examinations. During Christmas vacation another week of school is lost, and during the year a day is lost here and there. If we have 40 weeks per year, and but three recitations per week our maximum is 120 recitations, but it is fair to say that vacations, holidays, and examinations will not leave more than 100 recitations. In these 100 recitations we attempt to teach more than is attempted in other subjects that have five recitations per week or 200 possible recitations per year. Is it any wonder that chemistry and physics are considered difficult subjects?

Having but 100 recitations for the year's work, we must be sure that each lesson covers its full share of the load and that its subject matter is justly entitled to the time given. Too often we justify the presentation of subjects by the excuse that the material is worth while. It is all worth while when presented by a successful teacher, but being worth while does not justify its presentation when we consider that there are but 100 recitations for the *whole* subject. That being the case, it is necessary to look over the subject matter for the major points and then for the minor points until we have selected the most important fundamentals to build the course around. We must be careful not to select too much material, a thing teachers invariably do. We have grown up in the subject, and the many facts and theories all look important. We all have our little hobbies, and

when a committee of five or ten teachers work out a course covering the more important material, we find that practically the whole of chemistry has been dragged in; and, what is worse, that no two groups will agree on the same assortment of facts and theories. The most important part of a committee's work is the elimination of material in order that more time and drill can be given to fundamentals for their thorough mastery. A student who knows the more important phases of elementary chemistry thoroughly is much better equipped than the student who has been exposed to the entire field and has not mastered it. If we talk with our students one, two, or more years after they have left school, we find that they have but little of the information we presented to them, and too often they remember only minor points. A study of what the student retains, and a study of what we wish him to retain is worth while.

We may ask which takes precedence, descriptive material or underlying principles? Which is more important, chlorine and its properties, or oxidation and reduction? Is chlorine studied because of its important properties and uses, or, as an example of a very active oxidizing agent? Granting the importance of the properties and uses of chlorine, it still is but one step in presenting a fundamental idea. Which is better, to teach oxygen and chlorine as fundamental subjects, or to teach them as examples of oxidizing agents, since practically all of their important uses are as oxidizers?

Again we may ask, "What about industrial and domestic chemistry; do they require special courses? Are they our main objectives, or are they merely divisions to help us reach our objectives? How can a girl obtain a useful working knowledge of chemistry by studying disconnected bits of it with applications taken here and there from the home? What will she do when she finds a problem not previously studied?"

It is better that she have a grasp of the fundamental principles of chemistry *with the applications taken from the home* to help teach those fundamentals and to fix them in her mind as useful working principles. If she finds problems not previously studied, she is better prepared to master the new situation.

We may ask whether or not two courses are needed, one for those who will go to college, and one for those who will not. In the first place, we can present only a small amount of material in high-school chemistry and can hope to lay but a small foundation. If this foundation material is selected to give a student a broad view of chemistry, we find that the two courses are practically the same.

It makes no difference whether the student expects to go directly into the industries or into the home or to college, if he has a grasp of the simpler fundamentals, he is prepared to use his knowledge in whatever field he finds himself. These more fundamental principles are the same for a col-

lege course as for an industrial position. Do we have one set of laws for college chemistry and another for chemistry in the industries? Is not a knowledge of oxidation and reduction just as important in industrial work as it is in college? Because the college has not tied up the study of each law and fundamental with numerous illustrations from the industries, and because the industries are plodding along training their non-technical men in a cook-book fashion, it does not follow that they are not covering the same fundamentals. One teaches theory, so called, and the other practical routine; one is putting into practice the theory of the other.

Does the housewife have a set of laws in chemistry not used elsewhere? Does she use the same fundamentals? Girls may need illustrations within their experience which may justify a separate course for girls, but they need as much chemistry as do boys; more in fact, because they must have a working knowledge of organic chemistry.

If we make a careful survey of the field of chemistry, what are some of the underlying principles that we wish to present?

Minimum Essentials or Fundamental Principles

(*A*) *The intangible.* Science has given the world at least one great contribution, the *scientific attitude* or *spirit;* a desire for the truth for truth's sake, a willingness to experiment to that end, and the effort to give as unbiased judgment as possible which must be based on sound evidence. True, this is not a tangible thing that we can teach directly. It must be exemplified by the teacher in his attitude towards his work, his class, and the scientific world. We want at least some of this spirit carried away by the student consciously or unconsciously. We want it so thoroughly ingrained that he will carry it into other fields, even into politics.

(*B*) *The tangible.* We want chemistry students to have accurate ideas of acids, bases, and salts in a general way. We realize that most of the details will be lost, but that the general properties of each class must be driven home so that they are thoroughly mastered. The student should carry away with him a fair idea of solution and of ionization. To have an understanding of them, he must have some idea of the structure of matter, and a slight knowledge of the structure of the atom. Because many of the reactions that he meets in everyday life and in commercial work are those of oxidation and reduction, he must have a general idea of this subject in its simpler phases.

If the student does not appreciate the general idea of the quantitative features of chemistry, he will have but a hazy idea of the whole field of chemistry. For example: He must know that a spoonful of soda will not neutralize an unlimited amount of sour milk, even if he has never before associated soda and sour milk. Without this he misses the orderliness

and system which make chemistry a science and he fails to grasp the most basic fundamentals of the subject. The mere working of chemical problems does not put this over.

Chemistry must acquaint the student with chemical equilibrium and mass action, not in a mathematical sense but in a broad descriptive way. He should have the idea that energy plays a part in chemical reactions. If we are to have the work thorough, it is quite evident that we must be careful not to venture too far into some of these fields, but be content with the simpler fundamental ideas of each.

Some may want to add to this list, but very few will want to put any of these subjects into the secondary list or omit them altogether. Some may ask how we will balance facts and theories. Today there is very little theory that we need give to a beginning student, for modern research has eliminated the uncertainty and our theories are fast becoming established facts although they may still have the ancient title of theory attached to them. We can safely leave the real theory to the college.

Even if we agree on the fundamentals, we still have the problem of selecting the descriptive material to be used for teaching these principles. We have all had about the same general chemistry training and too often attempt to present the same material in an elementary way in our high-school classes that *we* studied in our freshman college course. In doing this we put so much emphasis on so many details that the student gets the idea that chemistry consists of many subjects that are only slightly related. Much relatively minor material is given undue importance. I know one successful teacher who spends at least three weeks, 10% of the year's work, on the oxides of nitrogen. Are they so important and such good illustrative material that we can afford that much time for them?

Look over the list of minimum essentials presented by the Committee of the American Chemical Society. Have they not given the student more illustrative material than he can digest? Why not select the most important material that is required to put over the basic principles of chemistry and omit the rest? If the colleges insist on requiring it, let *them* give it. They are the ones who are making the complaint about the poorly prepared high-school student, and they should be the first to insist on less material in order that what is presented can be mastered. The more one studies the chemistry courses that high-school students are required to complete and notes the great amount of information and the degree of difficulty at the time given, the clearer it becomes that our chemistry students are suffering from mental indigestion due to overfeeding. In addition to learning all of the facts taught in chemistry, we expect our students to be able to use these facts in working out new chemical problems. The latter is the phase of chemistry that many western colleges insist on, rather than a specified course.

If we eat a normal meal, our bodies can make some use of it; if we take double that quantity, we may get a reaction that defeats the object of eating. In like manner, we cannot expect our students to digest properly more than a limited amount of information that can be used in thinking and reasoning along chemical lines.

If we select the more important material only, we are leaving to the colleges much material which belongs to them, that has no place in an elementary course, such as finding the formula of a compound from percentage composition, etc. Much of the material that we do treat should be attacked from a viewpoint differing from that of the college. Take any normal boy from the senior class in high school and attempt to sell him an automobile. Is he first interested in how it is made or in how it runs? After he finds out how it runs by a trial spin, he may then be anxious to learn how it is made and why it works. Are our students so much interested in the development of the ionization theory as in the use and applications of it? I think not. The normal reaction is first to see results and then to learn about the how and the why. As a high-school course is too brief to give more than a working knowledge of ionization, the development of the reasons that lead scientists to believe in it, how we obtain atomic weights, etc., must be left to the college.

If the minimum essentials have been properly selected, we should have at least thirty lessons out of the 100 left for a study of those portions of chemistry which best fit the local needs. This means that the list of *minimum essentials* must be short.

The report of the committee of the American Chemical Society can do much to help or to handicap chemistry in America, and it is to be hoped that such a report will be carefully studied according to the *objectives there laid down*, especially in part two in which they say:

"2—To develop this service in chemistry around those minimum standard topics, and, in doing so, to see that these minimum requirements are *so well taught* that they may be built upon as a foundation in college." (The italics are mine.)

Let their report suggest real minimum essentials and not maximum essentials. In making the report truly minimum essentials, the committee can do much to relieve an already bad situation and one that is continually getting worse.

Summary

1. We should have minimum essentials that must be in all chemistry courses and that no teacher will want to omit. Select only the more important descriptive material in putting over the minimum essentials.

2. Colleges can depend on this much work being done and done *thor-*

oughly and can start where the minimum essentials leave off. At present they review the entire high-school course.

3. The student who does not take further work in chemistry will have much better working knowledge of chemistry.

4. Minimum essentials should allow sufficient time for teachers to round out the year's work, with material fitting the special needs of the class.

5. Minimum essentials will greatly assist the new teacher as it will show her where to place the most emphasis.

6. *Only those subjects should be included that can justify the time given to them when compared with the entire field of chemistry.* Only the most important principles and important descriptive chemistry should be studied. Each subject and the time given to it should be carefully studied before it is included, keeping in mind that but 100 recitations can be devoted to the entire year's work.

7. Give us less material and far greater thoroughness.

A PRACTICAL COURSE IN AGRICULTURAL CHEMISTRY FOR ELEMENTARY STUDENTS[1]

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Agricultural chemistry in its present generally accepted meaning treats of the composition of soils, crops and animals and of the mutual chemical relations of these in so far as they concern the means of human subsistence and comfort. It concerns human existence more closely than any other branch of applied chemistry involving as it does all the numerous products of plant and animal origin. It is also the most difficult branch of applied chemistry to understand as it includes not only much of mineral, plant and animal chemistry but touches upon physics, meteorology, geology and many other correlated sciences. This complexity of the subject does not make it an easy one for presentation to young students and yet I believe it can be made interesting and understandable if commencement is made in the right way.

The name agricultural chemistry, strictly interpreted according to its etymology, means the chemistry of field cultivation, by which is meant the chemistry of soils and soil fertility. The soil is of course the basis of all agricultural operations and logically agricultural chemistry should begin with a study of the soil. Soil chemistry, however, is such an exceedingly difficult and complex subject that it should not be presented first to elementary students.

[1] Address, February 7, 1925, before the Washington Association of Chemistry Teachers.

The first lessons for the young beginner should, in my opinion, be a simple course in the chemical constituents of plants. He should learn first by simple laboratory experiments that all plant organs consist of three portions, water, organic matter and ash. This can be shown by heating some common plant substances, such as a leaf of lettuce, a piece of apple, or a slice of potato in a nickle or porcelain dish in a hot water oven, and noting the water which condenses on a superimposed cover glass. If the cover glass be removed, all of the water contained in the product will escape and if the student should weigh his product before and after drying he can calculate the amount of water in the original material. If he should now heat the dried residue over a flame he will note the gradual charring of the residue. If a cold dry glass be placed over the burning material he will note the deposition of moisture and his attention should be called to the different source of this water from that previously expelled by drying, the latter being free and that produced by ignition being the result of chemical combination. The black residue of charcoal should be pointed out as an index of the element carbon which is present in all organic matter and the conversion of this carbon into carbon dioxide in the process of incineration should be demonstrated by the simple test with lime water. Finally, when the carbon is all burned away the residue of ash or mineral matter remaining in the dish should be noted. If the dish be weighed again the student can estimate the approximate amount of water, organic matter and ash in the original plant material. The alkaline character of this ash towards litmus paper might then be pointed out, as contrasted with the acid character of the juice of the original plant material and the difference explained. The presence of potassium in the ash may be indicated by a flame test and its characteristic lines in the spectroscope may also be shown if this instrument be available. Simple characteristic tests for lime, phosphoric acid, iron and other elements in the ash may also be indicated, and the sources of these elements from the soil be pointed out.

Having gained in this way a rough idea of the elementary composition of plant products, the student can proceed next to a separation of the simpler substances which make up the organic matter of plants. By grating a piece of potato in water and decanting the milky liquid into a cylinder he can be shown how to prepare starch, one of the most abundant food substances. He should be taught some of the simple tests and properties of starch and should be shown how this starch is dissolved by means of acids and diastase. Starch should be isolated also from wheat, corn, rice and other sources and the different appearance of the grains from the various sources under the microscope revealed. The conversion of starch into dextrin by heating should be shown and the industrial importance of starch in various industries should be indicated.

The student might next be taught how to prepare cellulose from straw,

corn stalks and other cellular materials, and experiments should be conducted upon the properties of cellulose. The universal distribution of cellulose in the vegetable kingdom and its industrial importance should also be emphasized.

The preparation of the carbohydrate sucrose by the student from some of its natural sources is also an instructive laboratory exercise but is not always easy of accomplishment owing to the difficulty of securing sugar cane, sugar beet, sorghum stalks or other raw material at the necessary stage of ripeness. Ordinary granulated sugar is a good material for demonstrating the properties of sucrose and commercial "cerelose" can be easily procured for demonstrating the properties of dextrose, which is the best example of a simple reducing sugar or monosaccharid. The student should compare these two sugars as regards sweetness and also as to their differences in chemical behavior with respect to the reducing action upon alkaline copper tartrate solution.

The preparation of a simple vegetable oil might next be taken up, after studying the carbohydrates. The extraction of peanut oil from finely ground peanut meal by means of ether or other solvents is an easy operation. Carbon tetrachloride, from its non-inflammable character, is the safest solvent for beginners. After extraction the solvent is distilled away and the oil is then in condition for examination. The saponification of vegetable oils by alkalis should be shown and the great importance of these oils for soap manufacture and other purposes should be pointed out.

As illustrating the occurrence of vegetable proteins, the production of gluten from wheat flour might be used as a laboratory exercise, the dough, formed by wetting the flour, being kneaded in a stream of running water upon a straining cloth until the starch is removed and the gummy mass of gluten left behind.

The students having thus learned by simple chemical tests some of the properties of the carbohydrates, fats and proteins, can be informed in a very general way of the role which these three great groups of substances play as food constituents. If desired the laboratory exercises upon the preparation of the organic constituents of plants may be extended to include the vegetable acids (the preparation of citric acid from the lemon being mentioned as an example), the tannins (as the separation of gallic acid from tea), the essential oils (as the distillation of eugenol from cloves), and many other products, these exercises all serving to widen the student's knowledge of products and processes. It is well, however, in an elementary course not to extend this phase of the subject too far in case it is desired to give a well-balanced presentation of the general field.

Having imparted to the student this brief survey of the composition of crops the teacher may next give him some laboratory instruction upon the chemistry of plant growth. One of the main points which the young stu-

dent should acquire is the reciprocal relationship of plant and animal life. Animals by inhaling the oxygen of the air consume food in their bodies giving off the same volume of carbon dioxide and the same number of calories as when the digested portion is burned in the crucible of a calorimeter. The student can demonstrate the evolution of this carbon dioxide from his body by blowing air from his lungs into a test tube of lime water and noting the turbidity. Plants on the other hand reconstruct the organic food materials which animals consume by recombining the waste carbon dioxide that is assimilated from the air with the water and other elements which are absorbed through the roots, oxygen being exhaled in this process from the leaves, just as carbon dioxide is exhaled from the lungs of animals. This exhalation of oxygen from green leaves can be demonstrated very nicely by having the young student saturate a glass of water with his breath and then place in this water underneath an inverted funnel the fresh leaves of any green plant, taking care that all air has been displaced from the body and stem of the funnel by agitation. If the tip of the funnel stem be now closed with a cork and the glass with the contents be exposed to strong sunlight bubbles of gas will gather upon the leaves. These will increase in size and gradually detach themselves, rising into the stem of the funnel. After a few hours' exposure enough gas will accumulate in the stem to enable the student to make the test for oxygen with a burning splinter of pine.

The photosynthetic process by which carbon dioxide and water combine in the green leaves of plants to form a carbohydrate should be explained to the student and he should demonstrate the presence of starch, which is formed in this reaction, by clamping a black band about a green leaf and then after it has been left in the sunlight for a few hours, plucking the leaf, dissolving the green chlorophyll by means of alcohol and then applying tincture of iodine. The presence of starch grains in the leaf will be indicated by the bluish coloration, the latter being absent in the place covered by the black band where the photosynthetic process was prevented owing to the exclusion of the sunlight.

After he has acquired a fairly accurate idea of the assimilation of carbon dioxide by the leaf the student is ready next to study the functions of the root in gathering the mineral constituents which are necessary for the life of the plant. This is best done by means of water cultures. The student has already some knowledge of these mineral constituents from his examination of the ash of vegetable matter. He should first of all prepare a nutritive solution which contains potash, phosphoric acid, lime, sulfuric acid, magnesia, chlorine, nitric acid and iron in the requisite amount. If seeds of corn, oats, or other grain, be now germinated in moist blotting paper and the young plant be fastened in a cork by means of cotton so that its rootlets are completely immersed in the nutritive solution, which

is placed in a glass cylinder, with the seed just above the surface of the solution, the plant can be raised to maturity if care be taken to change the solution every few days and to keep the cylinder wrapped in a dark paper. The student at the same time should attempt to produce similar plants by withholding one of the various necessary mineral ingredients, potash, phosphoric acid, nitrate, calcium or iron and note the unfavorable result. He will form in this way an idea of the importance of mineral matter to plant growth such as can be gained in no other way, and thus arrive at a true conception of the importance of fertilizers in crop production.

While the student is waiting for his water cultures to grow he should conduct a few simple experiments upon the chemistry of germination. He should be taught the preparation of malt from germinated grain and the diastatic properties of malt extract should be illustrated by means of a few simple experiments. The significance of the starch-dissolving enzyme diastase in the nourishment of the young seedling should be brought to the student's attention and the great importance of enzymes in plant and animal life pointed out.

The importance of the various essential mineral ingredients to plants can be demonstrated also by having the student attempt to cultivate plants in pure quartz sand. Similar experiments with garden soil should be conducted for comparison. The student in this way will familiarize himself with the differences in the properties of soil. The physics and chemistry of soils is, however, too complicated and difficult a subject for the high-school student to gain more than a very elemental knowledge. The interest of beginners can be held much better by laboratory experiments upon living plants and I doubt the wisdom of having them do much more with soils than to make a few simple experiments. The subdivision of soils into particles of different size by washing, decanting and settling is a simple laboratory operation and the absorptive property of clays and other soils can be shown by filtering through them dilute solutions of logwood or other dyes.

The importance of decaying organic matter in the improvement of the soil as regards tilth, moisture absorption and fertility should be pointed out to the young student and he should be taught something about the chemistry of decay. The resolution of straw or leaves into humus is too slow a process for the student to study with any degree of profit; he may, however, study to advantage the destruction of the soluble organic matter of the juice of apples, corn stalks or other vegetable products by watching the changes which they undergo upon fermentation with yeast. By sterilizing two portions of apple juice and then allowing one of these to undergo spontaneous fermentation by exposing to the air, the student will realize the wide distribution of the spores of the microörganisms which produce decay. The evolution of carbon dioxide from liquids undergoing

fermentation with yeast should be pointed out and the presence of alcohol should also be indicated. The conversion of this alcohol into acetic acid by acetifying organisms is another experiment which the student can easily carry out and the significance of this type of fermentation in the manufacture of vinegar should be mentioned.

If swampy areas are accessible the young student should be shown the evolution of marsh gas when the bottom of muddy pools is stirred with a stick. He should collect portions of this gas and test its inflammability. As a parallel experiment the student should heat some sawdust in a small metal retort and after collecting the evolved gas over water, make a similar test as regards inflammability. He might perform similar experiments with sugar, starch and cellulose.

The role of fermentation in breadmaking, sauer-kraut manufacture, pickling and other home operations may very well be taught at this point, with the intention of showing the student how microörganisms may act beneficially as well as harmfully. The experiment upon the sterilization of apple juice to prevent fermentation, previously described, can be used as an illustration of the method of processing which is used in preserving fruits, vegetables, milk and other products against decomposition.

In connection with the chemistry of fruits and of fruit utilization the student should be taught to perform a few simple experiments with the jelly-forming constituent, pectin. Crab-apples are good for preparing pectin; the skins of lemons and oranges may also be used. Commercial preparations for improving the jellifying quality of fruit juices are solutions of pectin and may be used for demonstrating its properties.

The chemistry of animal life and of animal products, constitutes a third division of agricultural chemistry. The experimenting with animals, which forms so important a part of modern agricultural chemical research is, however, unsuited for young students. The work is not only of a highly technical character but it requires a constant supervision such as the high-school student is unable to give. He can, however, conduct a few simple experiments upon animal products that will give him a good idea of certain fundamentals of animal chemistry. The experiments upon the distribution of water, organic matter and mineral matter in vegetable tissues can be repeated also upon certain animal tissues such as a thin slice of meat or upon certain animal products such as eggs and milk. The relative amounts of water, organic matter and ash might be determined approximately in each one of these products and some qualitative tests performed upon the nature of the ash constituents, such as calcium, phosphoric acid, iron, etc. A sample of bone might also be ignited for a determination of the ash and the high content of this in calcium and phosphoric acid indicated. The necessity of these constituents in foods as bone-forming material should be mentioned and the employment of phos-

phate of lime, prepared from bones or from mineral phosphate, as a fertilizer should be pointed out. The rendering of the phosphoric acid of bones and mineral phosphate more available to plants by treatment with sulfuric acid should also be referred to as the basis of the manufacture of superphosphates and the student might very well perform this reaction by a laboratory experiment upon a small scale. The cycle of phosphoric acid and calcium in agriculture can be explained to great advantage at this point, these constituents occurring first as inorganic mineral constituents of the soil, next as components of the organic matter of plants, which on being consumed by the animal are transformed into bone and other products; the latter, after slaughter of the animal, must be restored eventually to the soil again if a perfect realization of the cycle is to be maintained.

The distribution of the proximate components of animal products into fat, protein and carbohydrates can be easily demonstrated in the case of milk, in the same manner as shown for various plant substances. The separation of fat from milk is easily illustrated by extracting the dried solids with carbon tetrachloride; the protein can be prepared by acidifying skim-milk with acetic acid and filtering off the precipitated coagulum of casein; the presence of milk sugar can be demonstrated by evaporating the filtrate from the casein to dryness and its reducing properties can be shown by heating with alkaline copper tartrate solution. It should be pointed out, however, to the student that animals do not; to the same extent as plants, lay up carbohydrates as reserve material in the tissues of the body. The principal reserve substance which the animal deposits for its future needs of energy is fat, and the carbohydrate milk sugar, which is a distinctive animal product, is secreted only by the lacteal glands as a food material for the young. A characteristic test for milk sugar, consisting in the formation of the insoluble substance mucic acid upon oxidation with nitric acid, should be performed by the student.

Certain classes of animals such as insects do, however, elaborate and lay up outside their bodies reserve supplies of carbohydrates for the future need of themselves and their young in the form of honey. This we can call an animal product although it consists largely of the nectar of flowers, which the insect gathers in its honey sac and, after modification by its digestive organs, concentrates to a thick sirup in the hive. The insect feeds upon the honey and converts part of it into wax, which is a true product of insect metabolism. A large number of simple, interesting chemical experiments can be performed by the student upon a small piece of comb-honey, such as the separation of the sugars and wax, and chemical tests upon the properties of these.

The properties of animal protein can be best studied by the young student by making a few simple laboratory experiments upon egg albumen. The coagulation of the albumen of an egg into a white solid by the action

of heat is easily performed and the determination of the approximate temperature of this coagulation is a good exercise for stimulating the student's faculties of observation. A portion of this coagulated albumen should then be treated in a test tube with a solution of pepsin in dilute hydrochloric acid at a temperature of about 100°F. and the solvent effect of the pepsin upon the albumen noted. The student will thus form a better idea of what is accomplished by the digestive fluid of the stomach than can be gained in any other way. The student should next try the experiment of heating the solution of digested albumen, or peptone, and note its failure to coagulate. The actions of other digestive ferments, besides pepsin, may very well be illustrated at this point. The solvent action of the salivary secretion upon starch may be shown by gently warming a thin paste of starch with a few cubic centimeters of saliva. The familiar coagulating property of the stomach ferments upon milk can be easily demonstrated before the class by the action of rennet, conveniently supplied by the tablets sold for making junket. The pressing of the curd of milk, which is formed by the action of rennet, so as to liberate it from the liquid portion, or whey, constitutes the essential step of cheese manufacture, which might very well be explained to the student at this point. The distinctive differences between cheese and butter can be made the feature of several simple laboratory experiments.

Gelatin is another interesting animal substance with which the student should become acquainted. The separation of gelatin from bones by dissolving the mineral matter in hydrochloric acid can be performed if desired but it is perhaps better to pass this over and limit the work of the student to a few simple experiments upon a fragment or two of commercial gelatin such for example as its solubility in hot water, the jellifying property of this solution after cooling and the precipitation of the gelatin from solution by means of tannic acid. The property which tannic acid has of combining with gelatin can be made to serve as an illustration of the combining action of this substance with animal skins in the manufacture of leather, an important agricultural chemical industry about which a great deal might be said to the student.

The ramifications of agricultural chemistry are so extensive that there is practically no limit to the illustrations which may be selected for the purpose of instructing the young student. The production of the textile fibers, cotton, hemp, wool and silk are agricultural occupations and if the teacher so desires some very interesting chemical experiments can be performed upon these fibers in both the raw and manufactured condition. The difference in the behavior of vegetable and animal fibers to certain dyestuffs may, for example, be illustrated and the characteristic odors which they emit upon burning may be demonstrated. The difference in the appearance of these fibers under the microscope might also be pointed

out. The production of rosin, turpentine, rubber, copra, coffee, cacao, to say nothing of the gums, drugs, spices, perfumes and other commodities of tropical woods and fields are all agricultural occupations and the chemistry of these various products is not only a most fascinating but an endless study.

This hasty sketch is sufficient to show how agricultural chemistry touches almost every phase of the daily life of the young student; the air he breathes is purified by the assimilative action of crops and other plants; his food, his clothing, his shoes, the paper of his books, and countless other commodities with which he comes in contact are all derived from the raw materials of plant or animal life. The science taught to elementary classes should in my opinion give the least possible amount of theory and the most possible amount of simple, practical knowledge. I know of no other branch of applied science which can impart to the student so strong a realization of the importance of chemistry to our daily welfare. There are no better exercises than those of agricultural chemistry for stimulating the student's powers of observation, for teaching him to note resemblances and differences and for leading him to the deduction of truthful conclusions. A few simple experiments, well performed, are better than a multitude of tests hastily and carelessly executed. There is no better approach to science than a study of the simple phenomena and commodities of our daily existence. If the student gets a proper hold upon the elements of agricultural chemistry his interest in science will continue to grow and he may be counted upon in after-life to make his own contributions to the storehouse of knowledge.

A NEW METHOD OF TEACHING ATOMS AND MOLECULES

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Most chemistry texts introduce atoms and molecules by the decomposition of water. This is the traditional method. I do not know any other reason for using it.

I have discovered one serious objection to it. Many high-school students are puzzled by this reaction when it is the first chemical change presented to their minds. This trouble is due to the fact that the decomposition of water is not the simplest possible reaction but is complicated by having two distinct factors both of which are unknown to the novice. The quickest students, of course, will comprehend both factors, but we have slow students as well as quick, and it is more pedagogical to disentangle the factors of this problem and present them to the beginners one at a time.

The two factors are: (1) the atoms unite to form molecules as in mercuric oxide and hydrogen chloride, (2) one atom such as oxygen may unite with more than one other atom such as the two hydrogen atoms in the water molecule.

It is easy to keep the beginner's attention on the first factor by giving him, in the beginning, nothing but examples of binary compounds such as HCl, NaBr, KI, AgCl, etc., until this idea is familiar.

I use hydrogen and chlorine and discuss their union in connection with Avogadro's hypothesis. After it is clear that one molecule of hydrogen splits into two atoms and that one molecule of chlorine also splits into two atoms and that these atoms unite to form two molecules of hydrogen chloride, then it is easy for the beginner to take the next step and comprehend the divalence of oxygen in water and the trivalence of nitrogen in ammonia and the tetravalence of carbon in methane.

The following, taken from a pamphlet printed by the printing class in San Diego High School shows how I present these steps to the beginners. This pamphlet "Twenty-one Lessons in Chemistry" I do not use in the place of a chemistry textbook. I use it as a supplement to the ordinary text, giving my classes a lesson from the pamphlet at points where it will do the most good.

The first lesson, given the day I meet my beginning classes is a series of ten experiments with a burning match. Lesson Two is a discussion of why we study natural science in general and chemistry in particular, an answer to the question "What is chemistry?", definitions of matter, substance, body and properties and a statement and discussion of the law of properties, and the states of matter. Lesson Three discusses the beginnings of chemistry, the phlogiston theory, and the work of Priestly and Lavoisier. Lesson Four discusses elements and compounds, physical and chemical changes. By examples it shows that a "*Chemical change* is a change in which one or more substances are transformed into one or more different substances." "All changes in substances which do not transform them into different substances are called physical changes." The law of definite composition is discussed, stated and illustrated. Problems illustrating the law are solved and exercises suggested. Lesson Five is on some common substances illustrating what has been learned. Lessons Six to Eleven are on the measuring of materials. They discuss gas density, the molecular theory and aqueous tension, the laws of Boyle and Charles, absolute temperature and correction for difference of levels. The molecular composition of gases is explained and *proved* in Lesson Eight. This prepares the beginners for Lesson Twelve in which the relations between atoms and molecules, the topic of this paper, is taught. Here is Lesson Twelve:

Avogadro's Hypothesis and Atoms

Avogadro's Hypothesis

In 1811 A. D., an Italian scientist, Avogadro, in attempting to explain the laws of Boyle and Charles and certain other chemical and physical facts, elaborated the hypothesis we call by his name.

Avogadro's hypothesis assumes that equal volumes of any two gases contain equal numbers of molecules under the same conditions of temperature and pressure.

If this is correct, of course, it would follow that a molecule of a dense gas like chlorine would be heavier than a molecule of a light gas like hydrogen. In fact, if we assume that all the molecules of chlorine are equal in weight and that all the molecules of hydrogen are also equal in weight, it would follow from Avogadro's hypothesis that the weights of a molecule of chlorine and of a molecule of hydrogen bear the same ratio to each other as the gas densities of the elements. The weight of a chlorine molecule would therefore be 35.5 times that of a hydrogen molecule, since a liter of chlorine weighs 35.5 times as much as a liter of hydrogen.

In other words 1000 molecules of hydrogen would have the same volume as 1000 molecules of chlorine; although each chlorine molecule is 35.5 times heavier than a hydrogen molecule. We wonder how this is possible until we remember that in a body of gas the molecules do not fill all the space but move about freely within the container, just as a number of rubber balls might bounce about a closed room.

1000 molecules of hydrogen will fill a certain space at a certain temperature and pressure just as 1000 rubber balls can be bounced in a room of a certain size. Now it is obvious that the same room would hold 1000 balls of a larger size. We can see from this that 1000 hydrogen molecules might occupy the same volume as 1000 larger chlorine molecules.

Atoms—Atomic Weights—Molecular Weights

We learned that the gas hydrogen will burn in oxygen to form water vapor. Hydrogen will also burn in chlorine to form the gas called hydrogen chloride, HCl.

If hydrogen and chlorine are mixed and kept cool and in the dark, they will not combine at once, but if heated or exposed to bright light they will explode forming hydrogen chloride. If they are mixed in unequal volumes the gas in excess will be left over but if the volumes of hydrogen and chlorine put into the mixture are equal, all of both gases will combine. This is an interesting fact. Why should they combine in exactly equal volumes?

We have learned in the law of definite proportions that two or more elements always combine in definite proportions by weight, for instance 200 g. Hg unite with 16 g. O. The law of definite proportions applies to the union of hydrogen and chlorine also since 1 g. of hydrogen always unites with 35.5 g. of chlorine, that is to say, the reacting weight of hydrogen is 1, and of chlorine is 35.5 and the reacting volumes are equal, that is, 1 volume of H_2 + 1 volume of Cl_2 becomes 2 volumes of HCl. Then, by Avogadro's hypothesis, 1 molecule of hydrogen must join with 1 molecule

of chlorine to give 2 molecules of hydrogen chloride. This is surprising. We would expect only 1 molecule of hydrogen chloride instead of 2.

How is it possible for two molecules to be joined together and thus become two molecules of a different sort?

The following theory has been invented to explain this.

When one hydrogen molecule meets one chlorine molecule they both split in half and the halves join to form two hydrogen chloride molecules.

If we represent the hydrogen molecule by a small circle, and the chlorine molecule by a larger circle, we may represent this theory graphically as in Fig. 1.

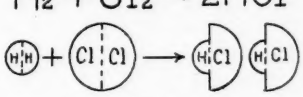

FIG. 1.

These pieces of molecules we call "atoms." The word "atom" by its derivation means "not divided." According to the atomic theory molecules may be divided in chemical changes, but atoms are not divided.

We believe that each molecule of hydrogen is made up of two similar atoms, also that each molecule of chlorine is made up of two similar atoms, but that each molecule of hydrogen chloride is made up of two dissimilar atoms, one of hydrogen and one of chlorine.

The gas density of hydrogen is 1, that of chlorine 35.5, that is, a given volume of chlorine weighs 35.5 times as much as the same volume of hydrogen. By Avogadro's hypothesis the chlorine molecule must weigh 35.5 times as much as the hydrogen molecule. Then since the hydrogen chloride molecule is composed of 1 hydrogen atom and 1 chlorine atom we would expect this molecule to weigh one half the sum of the hydrogen molecule and the chlorine molecule. That is, we would expect the gas density of hydrogen chloride to be one half the sum of the gas densities of hydrogen and chlorine, $\frac{1}{2}(1 + 35.5) = 18.25$, and experiment shows that 18.25 is the gas density of hydrogen chloride.

When we wish to represent the gas hydrogen we do not write the symbol H, but the formula H_2. Nearly all the elements except the metals, have two atoms to the molecule, as: Cl_2, O_2, N_2, etc. The metals such as gold, silver, tin, copper, mercury, sodium, etc., when they are heated up to the gaseous state are found to have only one atom to the molecule. Phosphorus has 4 atoms to the molecule (formula P_4) as has antimony (formula Sb_4). Sulfur in one of its known states has 8 atoms to the molecule (formula S_8).

If we simply wish to abbreviate the name of an elementary substance we may write the symbol without the small number following it, thus: H, Cl, O, N, P, etc.

However, when we write equations the formulas must always be written with the small numbers after them thus:

$$H_2 + Cl_2 \longrightarrow 2HCl$$

The coefficient "2" written before the "HCl" indicates that there are 2 volumes after the reaction. When H_2 is written without a coefficient, "1" is understood. We may read the above equation thus: "One volume hydrogen unites with one volume chlorine to form 2 volumes hydrogen chloride. It can also be read thus: 2 parts by weight of hydrogen, plus 71 parts by weight of chlorine becomes $2 \times (1 + 35.5)$ parts by weight of hydrogen chloride. That is to say the symbols always stand in an equation for the combining weights of the substances used.

These combining weights are also called the molecular weights because they represent the relative weights of the molecules. The combining weights of the atoms are called the atomic weights. The lightest molecule known is that of hydrogen, and the lightest atom is the hydrogen atom. The weight of the hydrogen atom is taken as unity, precisely 1.008 in this system of atomic weights and molecular weights, and it is called one microcrith. This weight, of course, is millions of times too small to be handled.

The hydrogen atom weighs 1 microcrith (approximately).
The oxygen atom weighs 16 microcriths (exactly).
The nitrogen atom weighs 14 microcriths (approximately).
The chlorine atom weighs 35.5 microcriths (approximately).
The sodium atom weighs 23 microcriths (approximately).
The mercury atom weighs 200 microcriths (approximately).

These numbers are called the atomic weights of the elements. A complete list of all the elements with their symbols and atomic weights is given in the appendix of most chemistry texts. The weight of the atom of an element in microcriths is its atomic weight. The weight of the molecule of a substance in microcriths is its molecular weight. Only elements have atomic weights but both elements and compounds have molecular weights.

The hydrogen molecule has two atoms, each weighing one microcrith and therefore its molecular weight is 2. The chlorine molecule has 2 atoms each weighing 35.5 microcriths and therefore its molecular weight is $2 \times 35.5 = 71$.

Observe that the molecular weight is found by adding together the atomic weights of the atoms in the molecule.

Hydrogen molecular wt. = 2
Chlorine molecular wt. = 71
Oxygen molecular wt. = 32
Nitrogen molecular wt. = 28
Hydrogen chloride (HCl) = 36.5 = 1 + 35.5
Mercuric oxide (HgO) = 216 = 200 + 16
Sodium chloride (NaCl) = 58.5 = 23 + 35.5.

We have learned that hydrogen is the lightest gas and that it is taken as unity in measuring gas densities. A certain volume of O_2 weighs 16 times as much as the same volume of H_2 and therefore the gas density of O_2 is 16. We can find the gas density of any gas by weighing a sample of it and dividing its weight by the weight of the same volume of hydrogen. For example, we find that 22.4 l. of ammonia gas S.T.P. weigh 17 g. and 22.4 l. of hydrogen S. T. P. weigh 2 g.; therefore the gas density of ammonia gas is $17 \div 2 = 8.5$. By Avogadro's hypothesis a certain volume of any gas has the same number of molecules as an equal volume of hydrogen. Therefore it follows that the gas densities of hydrogen and another gas would have the same ratio as the weights of their molecules.

Gas densities		Molecular weights	
H_2	HCl	H_2	HCl
1	18.25	2	36.5
H_2	O_2	H_2	O_2
1	16	2	32
H_2	Cl_2	H_2	Cl_2
1	35.5	2	71
H_2	Hg	H_2	Hg
1	100	2	200

The molecular weight of hydrogen is 2 times its gas density, therefore it follows from the above that we can find the weight of the molecule of any gas by first finding its gas density by experiment and then multiplying that gas density by 2.

RULE: To find the molecular weight of a gas find its gas density by experiment and multiply that by 2.

The answer is the weight of a molecule of gas in microcriths. For example, we weigh a sample of water vapor and find that it weighs 9 times as much as an equal volume of hydrogen at the same temperature and pressure. Its gas density is therefore 9. The weight of the water molecule is therefore $9 \times 2 = 18$ microcriths. That is to say the molecular weight of water is 18.

What is the molecular weight of methane (CH_4) if its gas density is 8? Ans. 16. CO_2 gas density 22; molecular weight 44. H_2S gas density 17; molecular weight 34.

Valence

We find that one volume of chlorine unites with one volume of hydrogen to form 2 volumes of HCl.

Chlorine plus hydrogen becomes hydrogen chloride.

$$\boxed{Cl_2} + \boxed{H_2} \longrightarrow \boxed{HCl}\,\boxed{HCl}$$

1 Volume + 1 Volume ⟶ 2 Volumes

Experiment shows that 1 volume of oxygen unites with 2 volumes of hydrogen to form 2 volumes of water vapor.

$$\boxed{O_2} + \boxed{H_2 \mid H_2} \longrightarrow \boxed{H_2O \mid H_2O}$$

1 Volume 2 Volumes 2 Volumes

If our 1 volume of oxygen has 1000 molecules, then by Avogadro's Theory our 2 volumes of hydrogen must have 2000 molecules, and our 2 volumes of water vapor must also have 2000 molecules.

1000 molecules O_2 + 2000 molecules H_2 ⟶ 2000 molecules H_2O

That is to say 1 oxygen molecule must unite with 2 hydrogen molecules to form 2 water molecules. We have learned that both oxygen and hydrogen molecules have 2 atoms each, therefore we may let a large circle represent the oxygen molecule and 2 small circles represent the 2 hydrogen molecules and we can represent the reaction graphically as in Fig. 2.

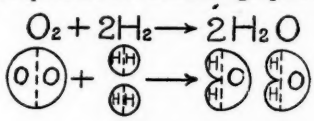

FIG. 2.

Oxygen differs from chlorine in that its atom is able to hold two hydrogen atoms in the molecule of the compound. We say that the valence of oxygen is 2 and the valence of chlorine and hydrogen is 1.

If nitrogen and hydrogen are inclosed together in a container and sparks of electricity passed through the mixture part of the gases unite to form ammonia gas. If this gas is separated from the mixture and decomposed we find that:

Ammonia	⟶	Nitrogen	+	Hydrogen
$\boxed{NH_3 \mid NH_3}$	⟶	$\boxed{N_2}$	+	$\boxed{H_2 \mid H_2 \mid H_2}$
2 Volumes		become 1 Volume	+	3 Volumes

The equation is written thus: $2NH_3 \longrightarrow N_2 + 3H_2$. The valence of nitrogen is three in this case since its atom will hold 3 hydrogen atoms in a molecule.

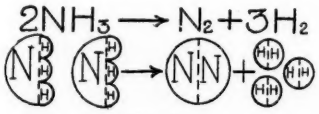

FIG. 3.

In methane (CH_4) the carbon atom holds 4 hydrogen atoms in the molecule. What then is the valence of carbon?

Phosphine is PH_3. What is the valence of phosphorus?

Lime is CaO. What is the valence of Calcium?

TANNING AS A SCIENCE

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A study of the history of tanning leads back to very ancient times. Before man learned to till the land he used the skins of animals for clothing. Later on he learned to tan the skin and then found it indispensable for clothing, shoes, armor and many other purposes. And so it is not surprising that the early Egyptians, Chinese, Greeks and Romans developed tanning as an art. When we read the literatures of the ancients, the references to leather and to tanning are found to be numerous.

The modern world needs much leather. Shoes, harness, upholstery, belting and luggage are only part of the many uses of leather. In other words, tanning is a basic industry.

We may next inquire what leather is. The main characteristic of untanned skin is its tendency to putrefy and decompose; any means of treating the skin so that decomposition does not occur may, under a broad definition, be termed tanning and the product of the process called leather. Speaking more strictly, however, leather is animal skin treated with certain kinds of tanning materials which yield an imputrescible material, which is at the same time usable and durable.

The skin of large animals, such as the ox, is made into heavy leathers like sole, belting or harness, while lighter leathers are derived from the skin of smaller animals like the calf, sheep and goat. A large proportion of the leather made throughout the world is produced in the United States. Two general types of tanning agents are employed: vegetable and mineral. In the former class are found a great variety of woods, barks, nuts, roots and leaves scattered over each of the five continents. All of these vegetable materials contain an astringent substance called "tannin," which we will describe later on. The mineral tanning agents consist chiefly of the salts of chromium and aluminum. Chromium compounds are the most widely used and most shoe upper leather is chrome tanned. Then there is a third type of tanning agent: oils, as, for example, in "chamois" leather.

Now let us briefly consider the operation of tanning, which is divided into six main steps:

1. Curing. The skin must be treated as soon as it leaves the animal's body in some manner so that it will not be decomposed when it reaches the tannery. This curing may be accomplished by treating with a salt (such as sodium chloride) or by drying the skin. If this is not done the protein splitting bacteria on the skin's surfaces quickly destroy it. Salt dehydrates the skin and acts as an antiseptic to these bacteria, while drying acts as an indirect antiseptic, since bacteria need moisture for their growth and activity.

2. Soaking. The first tannery procedure is to soak the cured skin in water. This softens the skin, making it uniformly pliable and removes dirt, etc., from its surfaces, as well as the curing salt from its interior, in the case of salted skin.

3. Unhairing. The skin, after soaking, is placed in a solution of some chemical which has the power of loosening the hair; lime-water is the chemical usually employed.

4. Preparation for Tanning. When removed from the unhairing solution, the now loosely held hair is pushed off the surface by mechanical means. Adhering particles of fat or meat on the flesh side of the skin are removed and the skin is now ready for tanning.

5. Tanning. In the case of vegetable tanning the skin is first placed in a very weak infusion of tannin, whose strength is gradually increased until after days, weeks or months, as the case may be, the skin no longer absorbs the tannin. Mineral tanning is usually much more rapid than vegetable.

6. Finishing. After tanning, the leather is treated with oil, to increase its toughness and improve its appearance, and is then dried. At this point it is also mechanically treated so as to render it solid or pliable as may be desired.

Simple as the foregoing may sound, there is probably no more complicated scientific field than that of tanning. This is quickly understood when we remember that animal skin presents many of the fundamental problems now confronting the medical world in its effort to understand the chemistry and physics of animal tissues and the action of bacteria or their enzymes. When we turn to the vegetable tannins we find that some of the ablest organic chemists have vainly endeavored to establish the composition of the general substance tannin. And so, despite the fact that the names of Lavoisier, Davy, Berzelius, Liebig and Emil Fischer are found in the history of tanning science, the field is still largely unknown. The past decade has, however, seen developments in new approaches to the work at hand which promise light. The newer knowledge in chemistry and physics and the realization that chemical and bacteriological investigations must go forward together (not separately) have already yielded interesting and promising results, which will prove valuable in other fields as well. In giving a brief resumé of the scientific side of tanning we will only attempt to point out the more important features and the experimental evidence upon which future developments will rest. This is best done by considering the skin and the tanning agents separately and then their combination. The several sciences involved may be briefly described as follows.

Bacteriology. All animal skin is covered with bacteria. During the animal's life and health these bacteria are unable to exert any deleterious

effect. As soon as the animal is slaughtered, however, they promptly proceed to multiply and to digest the skin. Bacteria multiply by fission and in geometric progession; thus, starting with one bacterium (under proper conditions), there will be four billion at the end of eight hours. This rapid growth explains the great speed of digestion. Bacteria digest food by means of the enzymes which they secrete.

There are many varieties of bacteria present on skin. It would be an endless task to isolate and identify each, and the results would scarcely justify the effort, since the tanning scientist is mainly interested in knowing whether or not they affect the skin and the processes of tanning. For this reason it has been found practical and logical to divide all skin bacteria into two groups. The first group is termed "proteolytic," *i. e.*, able to digest protein; the second group "non-proteolytic," unable to digest protein, or to a very limited extent only.

The growth, and hence the activity of bacteria, varies with certain conditions; temperature, absence of antiseptic influences, presence of digestible food and character of gaseous environment.

The problem before the tanning bacteriologist is to determine those conditions under which bacteria act in tannery operations, and their proper control. These conditions are found to be not unlike the factors present in the preservation and the curing of food-stuffs as well as in certain phenomena of animal life, both in health and sickness. Vegetable tan liquors ferment as the result of bacterial action.

Chemistry. It is readily realized that an understanding of skin, an organic tissue, involves the application of inorganic, organic, physiological and physical chemistry. Since skin, as well as almost all the tan liquors, is in the colloidal state, we must approach many problems from the standpoint of colloidal chemistry, that comparatively new and most interesting science. But there is rarely found any distinct border-line between bacterial and chemical phenomena in tanning science, except in mineral tannage. Chemical changes are usually the result of bacterial activity and vice versa. Lack of recognition of this fact is one of the chief reasons for the slow progress in the whole field.

Histology. This science deals with the structure of skin, as shown by the microscope. Thus the position of the different skin layers, the fat, hair follicles, etc., may be studied, as well as structure changes following decomposition, unhairing, tanning, etc.

* * * * *

Skin. Skin is the outside covering of animals. It has several functions; it protects the underlying body against mechanical injury, partially regulates the body temperature and aids in the removal of the waste products of the system. It falls into the general classification of connective tissue.

The morphology of most animal skins is similar; there are three general layers: epidermis, corium and adipose tissue. The epidermis and adipose tissue are removed after the unhairing process and before the skin enters the tanning liquor. Finished leather is really, therefore, tanned corium.

The three layers differ in composition. The epidermis is composed largely of the protein keratin, while the corium is mainly collagen, which is presumed to be the anhydrid of gelatin. This difference in composition is fortunate for the tanner, because keratin is much more soluble in lime solution than is the underlying collagen, thus enabling him, in the unhairing process, to remove the epidermis and preserve the corium. Corium is composed of water, proteins, fats and mineral salts, as shown in Table I.

TABLE I

	Steer per cent	Cow per cent	Calf per cent	Bull per cent	Heifer per cent
Water	61.000	63.110	63.350		
Collagen	33.200	32.160	30.800		
Albumin and Globulin	.700	.370	1.870		
Mucoid	.160	.130	.230		
Elastin	.340	.100	.020		
Fat	.760	.130	.450		
Ash	.450	.360	.500	0.490	
NaCl	.440	.350	.440	.480	0.441
CaO	.010	.004	.009	.012	.004
MgO	.003	.004	.007	.004	.003

It will be noticed that albumin and globulin, mucoid and elastin are present in small proportion compared with collagen. Their presence, however, has an important bearing in tanning.

The mineral or "physiologic salts" play an important role in skin. If skin is removed from an animal's body immediately after death and placed in distilled water, part of these salts diffuse out into the surrounding water. As this happens, a change occurs in the skin, one result of which is that the power of the skin to swell is decreased. On the other hand, if the water contains the skin salts in proper proportion, the swelling power is retained. This has an interesting analogy in physiological experiment. If an excised frog muscle is placed in distilled water it rapidly loses its ability to contract and to respond to stimuli; whereas, if the muscle is placed in the proper "physiologic salt solution" it may respond to stimuli for many hours.

Another interesting phenomena is the rapidity of the decomposition of skin following the animal's death. We are all familiar with the statement that a corpse becomes "cold and stiff" and know that this is followed by the body's decomposition. A very similar change occurs in skin. Immediately after death there is a very rapid formation of lactic acid. This acid may possibly be derived either from the glycogen (a sugar-like sub-

stance) which is present in the skin or from its mucoid. Coincident with this acid formation there is a decrease of the ability of the skin to swell.

The table shows that skin contains considerable quantities of fat. Information is gradually being accumulated as to the nature of this fat and its role in the skin's biological economy. A point of extreme interest has recently been found, namely the fact that the bulk of the skin fat is not loosely held, as had been supposed, but is in combination with the skin protein. Before the fat can be removed from the skin, this combination must be broken. The breaking may be accomplished by either chemical or bacterial means.

It will be noticed that the table shows interesting differences in the composition of the skin of young and old animals of the same species and in the two sexes. This data is of interest to the biological investigator, as well as to the tannery scientist.

At this point we may digress to speak of "swelling," which phenomenon is frequently encountered in tanning science, and throughout the medical world, under the term of oedema. When the house-wife throws gelatin flakes into lemon-water, the gelatin swells greatly and forms jello dessert. When a person becomes afflicted with certain diseases the body tissues take up water, swell and are termed oedematous. When rubber is thrown into an organic liquid like benzol, it too, swells. In other words, the phenomenon is quite general. Its cause, or rather the mechanism of swelling, is, however, still unknown. In the case of the jello it is assumed that the citric acid in the lemon juice combines with the protein gelatin causing it to swell; but this does not explain why. Attempts have been made to account for all protein swelling, based upon thermodynamical considerations and the application of Donnan's theory of membrane equilibria. These hypotheses are of quantitative nature and hence interesting. They have not yet, however, received confirmation under experimental conditions existing either in nature or industry. In the case mentioned of rubber swelling in benzol, where electrical phenomena are practically absent, a Donnan membrane equilibria could not exist and yet marked swelling does occur. It is probable that the solution of this problem must await the accumulation of additional experimental data. An understanding of protein swelling is ultimately essential in tanning science because the phenomenon is frequently encountered and because, too, the ability of skin to swell is one of the best indications of its condition and quality.

Tannins. Vegetable "tannin" is a body extracted from vegetable tissues; the word is a general term for a wide range of substances all of which possess the common property of combining with skin and precipitating gelatin. We know little of their definite composition except

that they seem to be derivatives of the tri-hydric phenol, pyrogallol, $C_6H_3(OH)_3$, or the di-hydric phenol catechol, $C_6H_4(OH)_2$. Pyrogallol tannin gives a blue-black coloration in the presence of iron salts, while the catechol shows green-black. This furnishes a rough qualitative means of their recognition. Most vegetable tannins when suspended or dissolved in water are presumed to be colloidally dispersed. In recent years the so-called "synthetic" tannins have come into limited use.

Many minerals combine with skin and form leather. As already mentioned, however, salts of chromium and aluminum are the minerals most widely used. Iron salts tan skin but the product is not very satisfactory, although during the war, German tanners employed iron salts to a limited extent.

Combination of Skin and Tanning Agent. No satisfactory evidence has yet been obtained as to the exact nature of the interaction between the skin and the tanning agent. And so, as in so many unexplored scientific fields, the subject is a popular one for hypothesis. These postulations range from the view that the interaction is of purely chemical ionic nature to the contention that it is purely physical, consisting of a mere coating of the skin fibers which prevents their putrefaction, and, also, their adhesion upon drying. Probably the method of interaction varies with conditions and it seems fairly certain that no single hypothesis can adequately explain all of the varied phenomena of the combination. It is a question of time only until this and many other perplexing, interesting tanning problems are solved, since research laboratories in many countries are now studying them.

QUESTIONS RELATIVE TO THE CORRELATION OF COLLEGE AND HIGH-SCHOOL CHEMISTRY COURSES

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Any attempt to correlate college and high school courses naturally calls for some form of differentiation in the college course between students who have had and those who have not had secondary school chemistry. Many teachers favor the establishment of an additional separate course of general inorganic chemistry for those freshmen students who have previously passed a high school chemistry course. These teachers broadly maintain that such differentiation should be made because it encourages high school chemistry as worthy of a recognized place in general education; it effects a desired pedagogical sequence between high school and college chemistry; and it is a just recognition of the student's previous work and attainment in chemistry.

The Committee on Chemical Education of the American Chemical So-

ciety has made a preliminary report[1] on the correlation of high school and college chemistry in which the following points were made:

1. The teaching of chemistry in high school should be encouraged.
2. Such a course should be given in high school that it will answer for students who go to college as well as for students who do not go to college.
3. A new course of chemistry must be outlined for the high school, taking into account both content and method.
4. Colleges must recognize high-school chemistry, at least, to the degree of having a different course for those students who have had high school chemistry.

The present paper does not question points (1), (2) and (3); nor would it disparage in any sense whatever the work and motives of the efficient teachers of high-school chemistry who merit all possible encouragement; but the somewhat imperative suggestion in point (4) that colleges must recognize high-school chemistry by having a different course for those who have had high-school chemistry, calls for comment since it would thrust upon departments of chemistry and upon curriculum committees of colleges an educational policy, the pedagogical advisability and ultimate utility of which may be seriously questioned.

Some factors to be considered in this problem have been clearly stated by A. B. Lamb:[2]

> How best to continue the chemical education of such students [those who already possess an elementary knowledge of the subject, such, for instance, as is acquired at our better high schools] is one of the most difficult problems which confronts teachers of chemistry in our colleges and universities. A time honored practice has been to ignore secondary-school preparation entirely and give identical instruction to these men and to real beginners indiscriminately. This was doubtless justifiable some years ago when chemical instruction was new in our secondary schools and was, naturally, poor; but today it can only be defended on the ground of necessity. The larger institutions recognize this where the number of elementary students is adequate, and either have arranged separate laboratory sections for the differently prepared students, or, better still, give them wholly separate instruction.
>
> But even when segregation of this kind has been secured, the problem is by no means solved. Those students who have studied chemistry in the secondary school have already done a large share of the simple, important and impressive experiments. The first freshness of their interest in, and wonder at, chemical phenomena has been lost. On the other hand, to trust that the average college student retains any clear conceptions regarding the abstract matter of his secondary-school chemistry, which is so important as a basis for further study, is to court disappointment. Besides, as every experienced college teacher knows, the very familiarity of such students with parts of the subject frequently leads to over-confidence about the whole of it—with disastrous results. Flagging interest then, hazy ideas about the principles of chemistry, and over-confidence are the special difficulties of the problem.

[1] *Ind. Eng. Chem.*, **15**, 534 (1923).

[2] "Laboratory Manual of General Chemistry," p. iii, Harvard University Press, 1916.

The statement that to give identical instruction to students who have and to students who have not had secondary-school chemistry "can only be defended on the ground of necessity" is questioned by teachers whose experience has taught them that differentiation is not necessary, provided that the college chemistry course is sufficiently differentiated in itself, as every college course should be, from the high school course. In other words, many university instructors maintain both in principle and practice that any natural science course in the college curriculum, regardless of the numbers of students enrolled, may be and should be so organized both as to content and method that it is neither necessarily nor directly a continuation or a correlation course of the previously pursued high-school course. Furthermore, such a general inorganic chemistry course is quite adaptable and equally beneficial to students who have and who have not had high-school chemistry.

The difficulties, noted in the above quotation, which are encountered by teachers who do and who do not attempt differentiation, may be successfully combatted by presenting a college course that is so far in advance of the student's previous secondary-school preparation both in its content and method, intensively and extensively viewed, that the student finds himself in a field of work wherein, according to his own testimony, his reliance upon his high-school chemistry to carry him on in college chemistry is of very brief duration. In fact, innumerable instances prove that the student's reliance upon his secondary-school chemical foundation is of pertinent value for not more than one half of the first semester of the college course, during which time the fundamental conceptions are being reviewed and completely redeveloped from newer and more comprehensive points of view.

Speaking intimately, a college or university freshman course may be *per se* so differentiated from the high-school course that it is no unjust hardship to the student who has passed a previous course to review the fundamental conceptions and complementary laboratory experiments as a concomitant and necessary prerequisite to his more mature college course. The manner in which this introductory review and redevelopment is presented is entirely within the comprehension of the student who did not have high-school chemistry, but who through the satisfactory fulfilment of the college entrance requirements is judged to be sufficiently competent to carry on the college course. His sole handicap is a sense of unfamiliarity, for a short time only, with certain fundamental conceptions and experiments that are more or less (too frequently less) familiar to those students who have previously had chemistry.

The necessity for repetition of the subject matter is expressed by many college teachers. H. N. Holmes,[3] making no apology for a non-differentiation policy, has written as follows:

[3] *Science*, **56**, 648 (1922).

> During this difficult freshman year the old facts of high-school chemistry must be dealt with in an interpretative spirit. When taken behind the scenes, so to speak, the student sees a new meaning in the subject. There is small doubt that unless all that has gone before, more or less loosely held in mind, is worked over into a solid foundation the student is chemically crippled for life. A certain amount of forceful repetition is the essence of good teaching. Even in the second, third and fourth years, we all find it profitable [and necessary] to repeat and expand what was presented in the freshman year of general chemistry. This makes the thorough chemist.

Teachers in colleges which require students to pass a rigid entrance examination in chemistry prior to their enrolment in the college also stress the necessity for repetition. For instance, Blanchard and Phelan[4] state that

> Experience has taught teachers that it is unwise to count too much upon an understanding of studies previously studied. Therefore, although this book is presumed to outline a course continuing from a previous course in high school, it was thought best to include the essential material of the high-school course.

If a college teacher finds "flagging interest. . . ., hazy ideas about the principles of chemistry, and overconfidence" to be the special difficulties of the problem in dealing with students who have had high-school chemistry, he can successfully obviate these difficulties by seeing to it that these students realize that they are being held individually responsible for a thorough review and redevelopment of the subject matter as it is presented in the college course. It has been found that this end can be effected by giving frequently to the class, without previous announcement, short, written quizzes. The class is thus kept on the *qui vive* at all times and the student reveals through his written answers whether or not he is continually reviewing and studying the subject matter of the course. The grades he makes upon his returned quiz papers usually reveal to him the haziness of his ideas and cure him of over-confidence. Concomitantly, those students in this college course who have not had high-school chemistry realize that they too must master the fundamental conceptions, quite new to them. In fact, they meet the requirements of this course as successfully as do those students who have had a previous course. Scholarship data substantiating these facts will be considered later.

This survey of opinions and facts tends to confirm a growing conviction that the differentiation in college chemistry classes between students who have had and those who have not had high-school chemistry is not only needless but also more apparent than real. This is a natural consequence because it is practically imperative that the majority of students in freshman college chemistry classes be, as far as possible, equally grounded in the principles and practice of general inorganic chemistry which is pre-

[4] "Synthetic Inorganic Chemistry (for first year college students)," John Wiley & Sons, p. iii, 1922.

requisite to any and all subsequent courses in chemistry. If differentiation is maintained throughout the entire freshman course, chemistry departments will then be confronted with classes of students of unequal preparation and fitness for subsequent work. We must, of course, always deal with students of unequal capacity, fitness and preparation, but is is a questionable policy to adopt any system of differentiation, which, *per se* will accentuate natural inequalities and lead at the end of the freshman year to a demand for further undesirable differentiation in subsequent chemistry courses which the differently prepared students may then desire to pursue.

Furthermore, regardless of the nature and extent of the student's previous training in high school, the motive and method of the college course may conveniently be such as not to call for differentiation. For instance, let general inorganic chemistry be a fundamental natural science course, open to any and all university students, designed to promote mental discipline and the acquirement of useful knowledge through the intensive study of different kinds of matter, the ultimate constitution of matter, and the phenomena (matter and energy transformations) which occur when different kinds of matter react one with another. The lecture and laboratory periods of instruction and work of such a course are complementary to each other both in motive and content. The purpose of the course is three-fold; (1) systematically to develop an understanding of the basic concepts, facts, terminology, hypotheses and laws of the science of chemistry; (2) simultaneously with the first purpose to develop, through the individual performance of numerous supervised experiments, the laboratory technique of general inorganic chemistry; (3) through drill in observation, experimentation, classification, and generalization, to sense the significance of laws and hypotheses, or, in other words, to develop an appreciation of the scientific method which may be retained as a permanent attitude of mind in the pursuit of any subsequent course of organized study. Such a foundation course in general chemistry necessarily precedes any other course in chemistry, and, as a key science, should also afford historical, philosophical and technical points of view essential to the thorough study of all natural sciences and related subjects. The motive of such a course thus briefly indicated, can be effected without differentiation as subsequent scholarship data will show.

Before considering these data, certain points relative to the possibility of standardizing courses must be taken into account, especially since standardization of both high-school and college chemistry courses necessarily precedes the adoption of any differentiation methods. Alexander Silverman, investigating the possibility of establishing a correlation between high-school and college chemistry, sent a very comprehensive questionnaire[5] to 971 high schools in the State of Pennsylvania following the

[5] *Science*, **48**, 179 (1918).

original communication with a second request. After a careful analysis and tabulation of answers, Professor Silverman concluded:

> It is evident from the variety of answers already received that standardization is necessary. For this purpose the state should have a permanent committee, as long as the United States Commissioner of Education is not empowered to establish standards and enforce them. The latter procedure is naturally more desirable, as it would enable all colleges and universities to plan their courses as continuation courses instead of repeating much of the material which students in some high schools have already covered.

This conclusion reflects the hopelessness of attempted standardizations because it remains to be demonstrated whether or not it is possible (1) to prescribe and (2) to enforce a system of standardization of either high-school or college science courses. Apropos of this, another dilemma confronts us. Suppose standardization of the content and method of courses could be prescribed—are we then able to prescribe and effect a standardization of the other half of the problem, namely the ability of the teachers of chemistry and the status of equipment, either in the high school or in the college, to carry out the method and to realize the motive of the course? The same syllabus for a given course in the hands of various teachers in different localities practically results in as many different courses as there are teachers and localities. This great uncertainty with respect to the status and efficiency of standardizations naturally stimulates doubt with respect to the advisability of differentiations which rest upon uncertain standards—too frequently standards in name only.

In the end, regardless of attempted standardizations and differentiations, does not the opinion and practice necessarily prevail that every department of chemistry must work out the nature and method of each course that it offers? These are determined by the ability of its staff, the sufficiency of its equipment, and the policy of the department—all in correlation with the regulations of the several faculty committees on entrance requirements, curriculum and schedule. It is therefore a questionable recommendation for a chemical education committee to state that "colleges must recognize high-school chemistry, at least to the degree of having a different course for those students who have had high-school chemistry." Whether such recognition and differentiation should be attempted depends on the one hand upon the college facilities and policy, and, on the other hand, the pedagogical advisability.

A study of the scholarship records of some college freshman classes in general inorganic chemistry (three one-hour lecture periods and two three-hour laboratory periods of instruction per week throughout the academic year) are of particular import since no distinction or differentiation whatever has been made either in the lecture or in the laboratory classes between those students who have and those who have not had high-school chemistry. This disciplinary and intensive course, conducted along the lines

previously outlined, is purposely as complete in content as it would be in the event that every student enrolled therein had had a previous course in high-school chemistry. But, in fact, about one-third of the students enrolled have had no previous chemistry. How then does the scholarship of those students who have not had high-school chemistry compare with that of those who did have high-school chemistry? Is the difference sufficiently pronounced to warrant differentiation?

Table I presents a summary in percentages of both the first and second semester grades of all students registered in a general inorganic chemistry course.* The numbers of students who received the respective grades A, B, C, D, E, F, and W were totaled. The ratio of each of these grade totals to the total ten-year enrolment gives the percentage of students who made the respective grades.

TABLE I

Grade	Per cent of total 10 year enrolment	
A (90–100)	5	
B (80–89)	13	
C (70–79)	25	
D (60–69)	32	75
E (50–59)	10	
F (0–40)	11	
W (withdrawn)	4	25
	100	100

In this general ten-year scholarship average, 75% of all students passed the course, *i. e.*, received the grade of D or above; 10% were conditioned, 11% failed and 4% were permitted or advised to withdraw. Table I may be regarded as registering certain levels of human intelligence of university freshmen but only with respect to the knowledge requirements of this particular course. It is herewith used as a norm.

In order to derive data bearing directly upon the extent to which scholarship in college chemistry has been enhanced by previous courses in high-school chemistry the following Table II is pertinent. It presents in col-

TABLE II

Grade	(*a*) Previous chemistry	(*b*) No previous chemistry
A	86	14
B	73	27
C	71	29
D	65	35
E	48	52
F	63	37
W	46	54

* Department of Chemistry, College of Liberal Arts, University of Cincinnati, during a ten-year period (1911–1922).

umn (*a*) for each grade (A-F) the percentage of students who have had previous chemistry and, in column (*b*), the percentage of students who have not had a previous course. The table is based upon a total three-year (1919–1922), two-semester enrolment of 776 students of which 508, practically two-thirds, have had high-school chemistry.

The percentage under (*a*) plus the percentage under (*b*) equals 100% and hence signifies, for example, that of all the students who made the grade of A during the three years, 86% previously had high-school chemistry while 14% did not, etc. This table above is of no immediate significance since the ten-year scholarship norm (Table I) shows that only 5% of all students make A, 13% make B, etc. Hence it becomes necessary to construct a third table, a correlation of Tables I and II, which will indicate for each grade the average percentages of the students who have had and of those who have not had high-school chemistry.

These data are obtained by multiplying one one-hundredth of each of the percentages in columns (*a*) and (*b*) for each grade in Table II by the normal percentage for each corresponding grade of Table I. Accordingly Table III shows, for example, that of the normal 5% of all students who made A, 4% had previous high-school chemistry while 1% did not have it; similarly for the remaining grades.

TABLE III

Grade	(*a*) Previous chemistry	(*b*) No previous chemistry
A	4	1
B	9	4
C	18	7
D	21	11
E	5	5
F	7	4
W	2	2
	66%	34%

The sums of the percentages in columns (*a*) and (*b*) show that 66% of the students have had previous chemistry while 34% have not. A revision of this table will afford more significant data. For example, by

TABLE IV

Grade	(*a*) 100% had chemistry		(*b*) 100% had no chemistry	
A	6		3	
B	14		12	
C	27		20	
D	32	79	32	67
E	8		15	
F	10		12	
W	3		6	
	100%		100%	

simple proportion, the 4% of A grade students in the 66% group, column (*a*), Table III, is equivalent to 6% of A grade students in a class, 100% of which has had previous chemistry. See column (*a*), Table IV. On the other hand, the 1% of A grade students in the 34% group, column (*b*), Table III, is equivalent to 3% of A grade students in a class, 100% of which has had no previous chemistry. See column (*b*), Table IV. The percentages for each of the other grades were thus calculated.

This table thus affords an index of the scholarship of the two groups of students who are pursuing one and the same course according to the specific methods and requirements previously outlined. It is highly significant that while the ratio of the number of students who have had to the number who have not had previous chemistry is 2:1, the ratio of the percentage of students who passed the college chemistry course, after having had high-school chemistry, to the percentage of students passing without having had high-school chemistry, is only 79:67, or in round numbers 1.2:1. This ratio is far below expectancy. It indicates that the previous course in secondary-school chemistry has not enhanced to any marked extent the scholarship of the students in the college chemistry course.

These figures and conclusions are cited not to disparage or reflect criticism in any sense upon the high-school chemistry courses but rather to emphasize the fact that the method, content and purpose of the college chemistry course may be so differentiated in itself from the secondary-school chemistry that further differentiation in the college classes between those students who have and those who have not had high-school chemistry is unwarranted and unnecessary.

A final comparison of the scholarship of the group, 100% of whom previously had chemistry (column (*a*), Table IV) with the ten-year average scholarship record (Table I) of the mixed groups of students in which no differentiation is made, is embodied in the following Table V.

TABLE V

Grade	(*a*) 100% had chemistry		(*b*) Mixed groups		Difference
A	6		5		1
B	14		13		1
C	27		25		2
D	32	(79)	32	(75)	0
E	8		10		2
F	10		11		1
W	3	(21)	4	(25)	2

The difference in scholarship is so small (1 to 2% with respect to each grade) that a policy of differentiation in classes, wherein about two-thirds of the students have previously had high-school chemistry and one-third have not, is neither pedagogically desirable nor advisable. The very small questionable gain in scholarship that might be effected through differentia-

tion can hardly compensate for the uncertainties, inconveniences and disadvantages which necessarily factor when differentiation is attempted.

Summary

1. The general inorganic chemistry course for freshmen in colleges and universities may be so organized in its content, method and purpose that it is distinctively a university course and therefore neither necessarily nor directly a continuation or correlation course of any previously pursued high-school chemistry course.

2. It represents upon a higher plane of instruction all of the essentials of the high-school course and much more, as briefly noted, thus effecting simultaneously a necessary repetition and a redevelopment.

3. This intensive, disciplinary, fundamental course is quite adaptable and equally beneficial to any and all students irrespective of whether they have or have not had high-school chemistry. This conclusion is attested by the scholarship data considered under Tables I–V.

4. The advisability and feasibility of colleges having a different course for those students who have had high-school chemistry is also questioned because noteworthy opinions indicate that such differentiation is frequently more apparent than real.

5. Real differentiation necessitates the establishment of some system of standardization of the content, method and purpose of both high-school and college chemistry courses. The bewildering number and variety, even of first class high schools, colleges and universities, and the related improbability of either prescribing or making effective any system of standardization, indicate that the question of the advisability and feasibility of adopting differentiation policies in colleges and universities can best be dealt with by their individual chemistry department faculties.

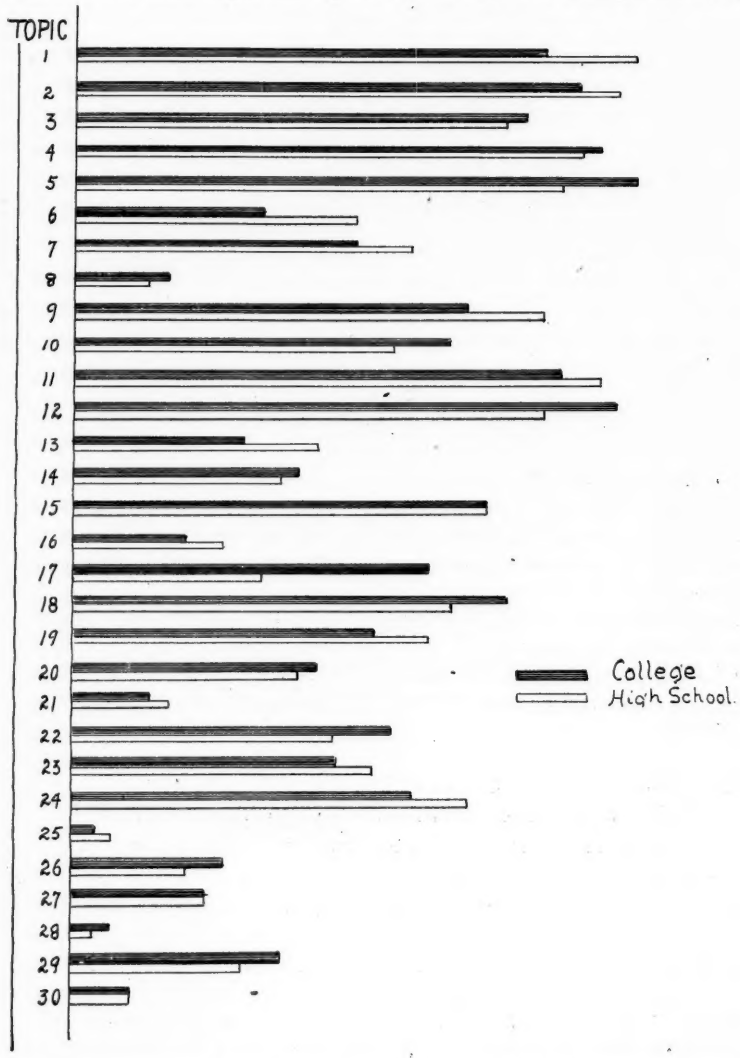
REPORT OF THE COMMITTEE[1] ON THE RELATIONSHIP BETWEEN HIGH-SCHOOL AND COLLEGE CHEMISTRY

Relationship between High-School and College Chemistry

Through the coöperation of a similar committee of the American Chemical Society, Neil E. Gordon, chairman, it was possible to send to each teacher of beginning chemistry in the state an outline of a suggested course in beginning chemistry with the request that the importance of the topics

[1] The committee reported in the Physics Chemistry Section of the Iowa State Teachers' Association on (1) the minimum requirements for a high-school course, and (2) the minimum equipment required for high-school work. The committee consisted of: F. E. Brown, Iowa State College; R. W. Getchell, Iowa State Teachers College; F. E. Goodell, Des Moines, West Des Moines High School; A. J. Burton, Des Moines, East Des Moines High School; H. F. Lewis, Cornell College; P. A. Bond, State University of Iowa, Chairman.

mentioned be classified in numerical order. Each teacher was asked to mark the five most important topics (1), the next five in importance (2),



etc. Also comments were asked for. Many of these comments were very valuable on account of the frank way in which they were made. It is hoped that the report of the committee will show that they were con-

sidered carefully. Thirty high-school teachers and thirty college teachers responded to the questionnaire.

The tabulation of the numerical data revealed three things which are discussed below.

1. While certain topics were rated quite uniformly within each group (*i. e.*, high school or college), there were a few topics concerning which there was marked disagreement.

For example, we note that college teachers rated the periodic system either very high or very low. It is apparent that some teachers regard it as a foundation stone in the teaching of chemistry, while others give it only casual attention. High-school teachers disagreed in a marked fashion on the topics of ionization, organic compounds and iron. There is probably no great significance to be attached to the differences in regard to the latter two topics, but the place and importance of ionization should be carefully considered by all teachers of chemistry.

In general, the agreement of individuals on the relative importance of the topics was very good. Therefore, no detailed statement on this point is presented.

2. The agreement between high-school and college teachers as to the relative importance of topics was also rather close. This is illustrated in the preceding diagram, where the length of line represents the reciprocal of the total rating on each point, so that the longer the line the greater the importance assigned to the topic.

1. Water
2. Oxygen
3. Hydrogen
4. Laws
5. Symbols, wt. and volume relations
6. Air
7. Nitrogen
8. Oxides of nitrogen
9. Nitric acid
10. Ammonia
11. Acids, bases, salts
12. Ionization
13. Sulfur
14. Oxides of sulfur
15. Sulfuric acid
16. Hydrogen sulfide
17. Periodic table
18. Halogens
19. Carbon
20. Carbon dioxide
21. Carbon monoxide
22. Sodium
23. Calcium
24. Iron
25. Zinc
26. Aluminum
27. Copper
28. Lead
29. Sources of organic compounds
30. Organic compounds

3. The rank in which topics were rated by the questionnaire is shown in tabular form below. College and high school are listed separately.

Rank	High School	College
1.	Water	Symbols, wt. and volume relations
2.	Oxygen	Ionization
3.	Acids, bases, salts	Laws and theories
4.	Laws and theories	Oxygen

Rank	High School	College
5.	Symbols, weight and volume relations	Acids, bases, salts
6.	Nitric acid	Water
7	Ionization	Hydrogen
8.	Hydrogen	Halogens
9.	Sulfuric acid	Sulfuric acid
10.	Iron	Nitric acid
11.	Halogens	Ammonia
12.	Carbon	Periodic table
13.	Nitrogen	Iron
14.	Ammonia	Sodium
15.	Calcium	Carbon
16.	Air	Nitrogen
17.	Sodium	Calcium
18.	Sulfur	Carbon dioxide
19.	Carbon dioxide	Oxides of sulfur
20.	Oxides of sulfur	Sources of organic compounds
21.	Periodic table	Air
22.	Sources of organic compounds	Sulfur
23.	Hydrogen sulfide	Aluminium
24.	Copper	Copper
25.	Aluminium	Hydrogen sulfide
26.	Carbon monoxide	Oxides of nitrogen
27.	Oxides of nitrogen	Carbon monoxide
28.	Organic compounds	Organic compounds
29.	Zinc	Lead
30.	Lead	Zinc

As is to be expected the rankings given by high schools and colleges are not exactly the same. There is a very definite emphasis in the mind of the college teacher upon the theoretical elements involved in the subject. It would seem that this is entirely appropriate. If, however, we examine the rankings for high-school and college chemistry in groups of five, we will find that a rather close agreement occurs. It is evident that the variation in emphasis upon certain topics is part and parcel of the different attitude which the high-school teacher will naturally take in dealing with the less mature mind of the high-school student.

Minimum Requirements for a High-School Course

The committee recommends that the teachers of high-school chemistry observe closely and follow in general the course outlined by the National Committee of the American Chemical Society. The report, which is not yet final, has been published.[2] There are but few changes from the original suggestions of the National Committee. The elimination, as required topics, of zinc and lead, and the addition of one new topic, "The Metals in General," are indicated.

The Iowa Committee has selected a very few topics for special emphasis

[2] THIS JOURNAL, **1**, 87 (1924).

and drill. It is understood that the preferences for topics shown in the second table and the report of the National Committee as to the total material are to be considered part of their recommendation. The special recommendations which follow are for topics which should be emphasized in such a manner that the student will have a definite working use of the principles involved in them. Under topic (7) by "Chemical Phenomenology" is meant the whole mass of descriptive chemistry, which the committee feels will naturally be an important part of any high-school course. Topic (6), "Oxidation and Reduction," was not included in the original report of the committee, but was added by a vote of the section.

It is recommended by the Iowa Committee that the following topics be drilled upon and emphasized so as to secure a definite mastery on the part of the student.

1. The correct writing of symbols and formulas; the balancing of equations.
2. The working of problems emphasizing weight relationships; making proportions.
3. The recognition of acids, bases and salts and a clear fixed idea of their inter-relations and reactions.
4. Some knowledge of ionization as a phenomenon. Drill on the proofs of ionization and also the formulation of ionic equilibria may be left for college.
5. The securing of a knowledge of gas laws either in physics or in chemistry.
6. Oxidation and reduction.
7. A general knowledge of chemical phenomenology.

It is hoped that if these recommendations are followed, the student will have given to him in high school a preparation for which he can actually attain credit through advanced standing in his college work. At the same time these recommendations are made few and simple in order that the high schools may not be handicapped in teaching students those things which will give them a broad view of the usefulness of chemistry in practical life, and that the high-school course may be of full value to those who do not expect to continue chemistry in college.

The Minimum Equipment Required for High-School Work

It is especially difficult to estimate the cost of equipment, for the reason that, when necessity requires, the teaching of chemistry is practicable with far less apparatus than is usually listed. An enthusiastic teacher with a few bottles, chemicals, test tubes, and possibly a flask or two, can carry through the subject such a class as might occur in some of our smallest high schools with entire profit to them. It must be confessed, of course, that much depends upon the teacher and his ability to adapt himself to circumstances.

Another element which is involved is the total cost of desks. The number of these required will depend upon the number of students registered in the course and the number of sections into which it is possible to divide them. Our larger schools having more than twenty-five pupils in chemistry will naturally divide them into two or three sections, each of which will use the same desk equipment in rotation and therefore may be accommodated at a cost only slightly greater than that necessary to accommodate one section. In making the estimates which are noted below a unit of twenty students has been taken and the costs are given for good laboratory equipment. If these seem excessive it should be noted that while no luxuries are included in the estimates made, still the cost of desks, and to a certain extent of equipment, may be lowered to fit special cases.

ESTIMATED COST

Desks, including plumbing, water, gas and electric connection, 2 tables accommodating twenty students in one section	$1200.00
Equipment for a lecture table for a separate room as provided for lectures	250.00

APPARATUS

Equipment for 20 lockers	$200.00	
First year's breakage	40.00	
Reagent bottles, 20 sets of 4	15.00	
Glass tubing, 25 lbs.	10.00	
Two blast lamps	10.00	
Ten pneumatic troughs	5.00	
Three Kipp generators	15.00	
Water still	40.00	
General reagent bottles, 100	20.00	
		355.00
Chemicals		150.00
Total		$1955.00

This shows a cost of $2000 for the equipment of a laboratory which would be satisfactory for the teaching of first year chemistry in the average high school of this state. This laboratory could be arranged by proper planning of desks, for accommodating under the direction of one teacher, forty to sixty students. Naturally, not all the items which would seem necessary to any individual teacher have been included, but usually these can be purchased at a small cost and, in many cases, some of the articles which were included in the students' sets according to our estimate could be dispensed with in favor of apparatus which the teacher might substitute for it. Estimates are based upon the cost of materials at the State University of Iowa in Freshman chemistry, where students are given what they need but nothing more, strict economy being observed in caring for the elementary students.

The largest single item in this estimate is for desks and plumbing. A much cheaper desk may be used when necessary. Any table with a sink at the end, or at each end if very long, may be used temporarily, or where cost is the determining factor. Enameled sinks may be substituted for the alberene stone used in the estimate and lockers for apparatus may be dispensed with where very small classes are concerned. A table of this kind might run as low as $150.00 for this number of students; without lockers, considerably less.

In case gas is not available, alcohol can be used as a fuel. Used in connection with a gasoline blow torch or two, practically all laboratory operations can be accomplished with it.

It would seem from these estimates that practically any high school of accredited rank could provide for the teaching of chemistry. That it should do so is becoming increasingly apparent as the fundamental importance of chemistry is being more largely appreciated by those interested in educational values.

NITROGEN: IN WAR AND PEACE*

CHARLES H. STONE, ENGLISH HIGH SCHOOL, BOSTON, MASS.

Chemistry is always a fascinating subject of study. It is never-failing in its interest, in its appeal to the imagination, in its problems to be solved, and in its continued revelations of new possibilities. If Solomon were writing Ecclesiastes today and could have a chance to get a little insight into some of the marvels of modern chemistry, I do not think he would have occasion to mourn over a belief that "there is no new thing under the sun."

One of the interesting and surprising things is the remarkable change in properties which an element undergoes when it passes from the free into the combined state. Take, for example, the element carbon, that very sedate and respectable Ethiopian member of the chemical community. In the free state, its character is as irreproachable as that of Dr. Jekyll in the story by Stevenson. But let carbon go into partnership with its neighbor oxygen and the firm is called carbon monoxide which has all the bad qualities of Mr. Hyde and snuffs out your vital spark when you are working under your car in a closed garage. If carbon takes on another oxygen, it changes again and this time it becomes "a jolly good fellow," putting the pep into your soda-water at the drug store, raising the housewife's bread in the kitchen, and just for the fun of the thing blowing out the corks from your bottles of home brew stored in the cellar. Like Puck in Midsummer Night's Dream, it is up to all sorts of mad pranks, like the

* Paper read before The Chemistry Club, Tufts College, Dec. 10, 1924 and the Scientific Society, The Phillips Exeter Academy, Feb. 21, 1925.

one now shown. I pour some concentrated hydrochloric acid upon some bits of marble in this strong bottle and insert the cork firmly. The lively carbon dioxide, struggling to escape, thoughtlessly takes the cork along with it—as you see.

You will readily think of other elements which undergo equally marked changes in passing from the free into the combined state. Hydrogen and sulfur, sodium and chlorine, are examples, and there are many other illustrations which come to mind. The compound does not reflect the characteristics of the elements which compose it.

Among all the elements, it seems to me, there is none which shows a more marked change in character in the combined state as compared with the free state than does the element which I have chosen for the subject of this evening's talk. In the free state, inactive, apathetic, harmless; in the combined state, restless, violent, dangerous; the element nitrogen seems to combine the opposing qualities of Dr. Jekyll and Mr. Hyde. It is kindly and peaceful in the one state, but mighty and murderous in the other.

Our modern civilization in times of peace depends to a very large degree upon nitrogen and its compounds, and in modern warfare we should be helpless without its aid. But, speaking of war, let us go back a bit.

In the prehistoric days when the world was young and men were just getting a little farther away from their arboreal ancestors (if you believe in Darwin's theory) or were falling from their high estate (if you are a fundamentalist), we can picture some fine morning when John Caveman met Bill Mudhut. In the course of conversation John may have made some slurring allusions to the cut of Bill's whiskers or Bill may have made certain sarcastic remarks about the style of John's trousers (if they had any trousers in those days) and thereupon trouble began. They fought it out. Chemistry being then in its infancy, these prehistoric chemists probably settled their quarrel with the chemical most easily obtainable and fought to a finish with cellulose in the form of clubs. Some thousands of years later, chemical warfare had advanced sufficiently so that Henry Stonehatchet and Isaac Quartztip settled their little differences with another chemical substance, using silica in the form of arrow heads and spear points. Gradually, as time went on, other and more artistic chemical ways of killing each other were developed but no great advance was made until the discovery of the chemical process of making iron gave a new weapon to war and Rome conquered the known world with the famous short sword. A thousand years then elapsed without much change until, about the year 1265, Roger Bacon, a monk, compounding chemicals in his monastic retreat, blew the cat out of the window and his pestle through the ceiling when he tried to grind together sulfur, charcoal and niter. Probably Roger was the most astonished man in Great Britain and little understood

what had happened. We do not know what the cat thought, but we have the record of that explosion which started the nitrogen era which has lasted down to this present day.

A mild imitation of Roger's experiment may be given by striking a mixture of sulfur and potassium chlorate a severe blow. Lay the powder on an anvil and strike it with the hammer. Do you wonder the cat went away from Roger's place?

In an old book of cooking recipes, one finds directions for making rabbit stew beginning as follows: "First catch your rabbit." Before we begin talking about the various "stews" which the chemist calls compounds and which we are to consider from the nitrogen standpoint, let us first see how we are to go about to catch this element so that we can use it.

You all know that nitrogen occurs free, forming about four-fifths of the air. If you are good at arithmetic and know that air exerts a pressure of 15 pounds per square inch, you can figure out that 12 pounds per square inch is the pressure due to nitrogen, and that on one acre of surface the weight of nitrogen is about 420 tons. Nevertheless with all this nitrogen at our elbows, it is so lazy, so inert, that we cannot get it to do anything while in the free state. It is true that certain plants like clover, peas and beans, have the power to convert air nitrogen into soluble nitrites and nitrates in the soil, but the amounts formed are so scattered that in no one place is any considerable quantity produced, although the total amount of these nitrogen products is of great value to the agriculturist.

There is only one considerable source of combined nitrogen and that is in the Chile saltpeter beds of South America. Here vast quantities of sodium nitrate were formed ages ago, but the increasing demands upon these beds for the world's supply during the past fifty years have brought them down so that the end of this source of nitrogen is in sight. It appears, then, that we must look elsewhere for our future supplies of this needful element, and catch our nitrogen rabbit out of the air.

If nitrogen were a little more sociable towards the other elements, our problem would be easy, but it is not "a good mixer" and has to be encouraged in all sorts of ways, like the bashful boy at the Sunday School picnic. You know how the bashful boy finally succumbs to the wiles of the pretty girl on such occasions. Well, we have to employ "pretty girls," called catalytic agents, to bring nitrogen into association with the other elements to form compounds. We have to be careful, though, that we do not get exactly the opposite result from what we want. I have here on this metal plate a mixture of powdered zinc and dry ammonium nitrate powder. You see there is no action. You will notice that our nitrogen is shut up in the prison called ammonium nitrate. I will just let a drop of water fall on this mixture. You see what happens. The

zinc, instead of combining with the nitrogen as we might have wished, takes a fancy to unite with oxygen, and the nitrogen gets out of the way as fast as it can, according to this equation,

$$Zn + NH_4NO_3 \longrightarrow ZnO + 2H_2O + N_2$$

Before Germany started out to conquer the world in 1914, Prof. Haber had worked out a process for combining nitrogen with hydrogen to form ammonia, using platinum gauze as a catalyst. The mixed gases were passed under high pressure over the heated platinum and a yield of some four or five per cent of ammonia was obtained.

Prof. Ostwald took the next step and perfected a process for converting Haber's ammonia into nitric acid. Ammonia and oxygen were mixed and passed over a heated catalyst. One five-hundredth of a second of contact with the catalyst caused 85% of the gases to combine as shown in this equation:

$$NH_3 + 2O_2 \longrightarrow HNO_3 + H_2O$$

Without the processes of Haber and Ostwald, Germany would not have been able to keep the war going more than a year, for the British had unkindly sunk the German fleet in the South Pacific and thus cut off the Germans from their supply of sodium nitrate from which nitric acid, the parent of explosives, is made. But air nitrogen took the place of the Chile salt and enabled the Germans to continue the war for four years.

Under the direction of a Tuft's graduate, Dr. A. B. Lamb, now of Harvard, a new catalyst has been discovered for the Haber process by which the yield has been increased from 5 to about 13%.

Another process for fixation of nitrogen has been worked out by Prof. Bucher of Brown University. He passed producer gas containing nitrogen through a heated tube filled with coke and soda ash with iron as the catalyst. His equation for this is:

$$Na_2CO_3 + N_2 + 4C \longrightarrow 2NaCN + 3CO$$

The American Cyanamide Co. passes nitrogen over white-hot calcium carbide according to the equation:

$$CaC_2 + N_2 \longrightarrow CaCN_2 + C$$

When the cyanamide is treated with superheated steam, ammonia is formed as shown by the equation:

$$CaCN_2 + 3H_2O \longrightarrow 2NH_3 + CaCO_3$$

Some of the uses of this form of combined nitrogen are shown by the chart on the board. Time does not permit a discussion of them.

So you see there are various ways of catching nitrogen. There are several other methods for nitrogen fixation but we cannot consider them now for lack of time.

What shall we do with our nitrogen now that we have caught it? Let us consider its value in war. When war begins, our first thought may well be explosives; and in this field nitrogen reigns supreme. The last war was really a battle between chemists in which nitrogen was a most important factor. The next war may be a battle of war gases in which the chemist will be the principal figure.

Black gunpowder has been known and used since that famous day of Roger Bacon's experiment. He advocated the use of gunpowder in warfare. It was first used at the battle of Crecy in 1346. As a military explosive, however, it has practically become obsolete, more powerful explosives which do not make smoke having taken its place.

I have here a little gunpowder which I will load into this glass cannon called a test tube. We will now insert the bullet, in the form of a cork stopper, and support the whole inside this metal tube so that only a bit of the glass shows at the lower end. Now I heat the projecting end of the tube and you hear what happens. In the excitement of the moment, the different atoms of the components of the powder rearrange themselves, and nitrogen emerges triumphant like the half-back who carries the ball through a welter of opponents to a goal. I don't know how to write the equation for a foot-ball play, but here is the equation for the explosion which you just heard.

$$2KNO_3 + 3C + S \longrightarrow K_2S + 3CO_2 + N_2$$

There is also a lot of noise but the equation does not show that.

Much more powerful and satisfactory than gunpowder is guncotton, discovered by Schoenbein in 1845. Here is a specimen which was made in my laboratory by treating cotton batting with mixed nitric and sulfuric acids for fifteen minutes and then washing the cotton with innumerable changes of water until the maker was in the condition described by Mrs. Magillicuddy who complained: "Me back is bruk wid washin'." Much washing is necessary, however, for every trace of acid must be removed.

Guncotton does not look much different from ordinary cotton, but the two kinds of cotton burn at different speeds. I will burn a bit of ordinary cotton batting and you note how it burns. Now if your honored president will step up here and hold out his hand I will lay a strip of guncotton on his outstretched palm and ignite the cotton, just to show you how brave he is. You see how the guncotton burns, pfft! It reminds one of that poem by Holmes in which he describes how The Wonderful One-Hoss Shay went to pieces:

> "All of a sudden and nothing first,
> Just like soap-bubbles when they burst."

The speed of the burning can be shown in another way. Here is a small glass funnel with a sheet of copper gauze laid over its top. I insert the

stem of the funnel in the tube of a Bunsen burner. Then I make a little heap of gunpowder in the center of the gauze. Across the gunpowder I lay a strip of the guncotton. Now I ignite the guncotton. You see the gun powder remains unaffected. Now I will ignite the gas but the powder does not ignite. It seems to have fireproof qualities like the coal sold by the Yegg Coal Co. last winter. If I turn the flame low, however, the powder ignites and goes off in a cloud of smoke just as the devil was supposed to do in the days when people believed in necromancy and witchcraft.

Since the exact formula of cotton is not known, we may err in our formula for guncotton, but the U. S. Govt. publications states that if cotton has the formula $(C_6H_{10}O_5)_x$, the endeka nitrocellulose is probably nearly correct for guncotton. The preparation, therefore, of guncotton may be represented by the equation:

$$C_{24}H_{40}O_{20} + 11HONO_2 \longrightarrow C_{24}H_{29}O_{20}(NO_2)_{11} + 11H_2O$$

Now guncotton doesn't look like that formula, does it?

When guncotton is exploded, not burned but detonated, the speed of the explosive wave is estimated at about 25,000 feet per second for packed cotton, or about five miles a second. You would have to go some to get away from a guncotton explosion. Even Longfellow's Hiawatha who

> "could shoot an arrow forward,
> And run forward with such swiftness
> That the arrow fell behind him."

wouldn't have any show at all in running away from an explosion of guncotton. Do not confuse the speed of explosion with the speed of burning. We have just seen guncotton burn, but it explodes infinitely faster than that.

Another powerful nitrogen explosive is nitroglycerine. This is not a nitro compound at all but is really a glyceryl ester as the equation shows:

$$C_3H_5(OH)_3 + 3HONO_2 \longrightarrow C_3H_5(NO_3)_3 + 3H_2O$$

I did not bring any of this material for I did not wish to have the fate of the boy in the express office who, seeing that a certain box was leaking a yellow oily liquid, got a hammer and nails and proceeded to nail up the box. Just about then that boy went away from there. He never came back on Saturday night for his week's pay and the railroad company had to build a new station.

Nitroglycerine is used in the manufacture of dynamite and numerous other explosives which I cannot now discuss. When nitroglycerine is soaked up by guncotton and vaseline added and the whole treated with acetone we get as a result an explosive called Cordite. Here is a small sample loaned to me by Prof. T. L. Davis of Massachusetts Institute of Technology. Enormous quantities of this were used during the war. The girls in the English explosives factories used this for chewing gum, but I think I prefer Mr. Wrigley's variety.

It would not be advisable to detonate here such high explosives as T N T or nitroglycerine, but we can illustrate the decomposition of these substances with a material which decomposes slowly enough so that you can watch the progress of the action. I will ignite this little heap of ammonium dichromate and you see how the decomposition proceeds.

$$(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + 4H_2O + N_2$$

The "green tea" which is formed is, of course, the chromium oxide. We notice in this case as in all the others how eager nitrogen is to escape from its compounds and to resume its bachelor life of ease and laziness.

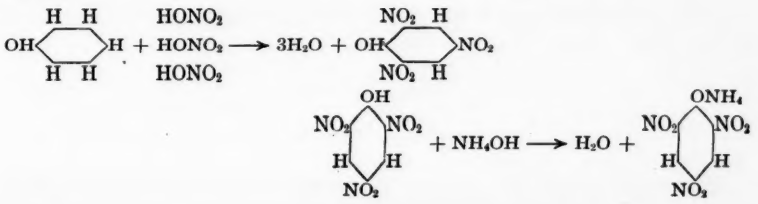
Smokeless powder is nitrocellulose gelatinized with ether-alcohol and passed through presses from which it emerges in cylindrical form pierced with seven small holes. These holes are to increase the surface, as the powder burns largely from the inside so that an increasing pressure is obtained as the projectile moves forward in the barrel of the gun. These three samples show the point. The first has not been fired; the second was fired once in a gun too small for it; and the third has been fired twice. You notice how the size of the holes varies in the three samples.

Under ordinary conditions smokeless powders simply burn. I hold this piece of the powder in my fingers and ignite it. It burns and I blow out the flame. I ignite it again and blow it out. It does not explode. A detonator will explode it, however.

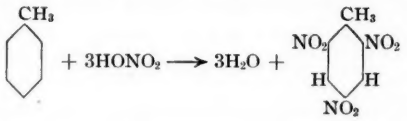
Another high explosive is picric acid. This specimen was made in my laboratory at the English High School. If you remember your Greek you will recall the word πικροσ which means bitter. Picric acid has a bitter taste, hence the name. The French call it melinite, the English call it lyddite, and the Japanese call it shimose but it is just as deadly under one name as under another. Picric acid forms highly sensitive compounds with metals and must be kept in non-metallic containers. It is exploded by detonation. The acid itself is not sensitive to ordinary shock.

Here is a sample of ammonium picrate made in my laboratory. This is formed in two varieties, red and yellow. It is not sensitive to ordinary shock and can be handled with safety.

Picric acid is made by nitrating phenol, and the ammonium picrate is made by neutralizing the picric acid with concentrated ammonium hydroxide.



The genial Germans who gave us the idea of Santa Claus also gave us another idea in the shape of tri-nitrotoluene or T N T which may be translated That Nitrogen Terror. It is made by nitration of toluene.



Here is a sample made in my laboratory. It is safe to handle and is set off with a detonator.

The most common detonator is mercury fulminate. I have made this from mercury, nitric acid and alcohol, but it is extremely sensitive and I did not bring any. It has the formula $Hg(ONC)_2$.

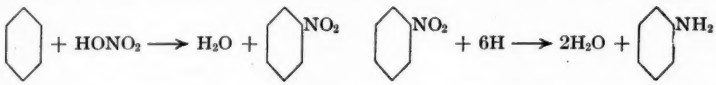
As an example of what we mean by "sensitive" I have here a little nitrogen iodide which I will touch with this feather. "Tickled to death" expresses the action perfectly.

Nitrogen also forms some of the gases used in chemical warfare, such as hydrocyanic acid, HCN, and chlorpicrin or nitrochloroform, CCl_3NO_2. The last is a lachrymator or tear-compelling gas. When a shell loaded with this gas explodes in the trenches where the men are without gas masks, the soldiers are so overcome by the generosity of the enemy in presenting them with this unexpected evidence of their regard, that they just sit down and cry about it. It puts them out of commission entirely. But it is time that we turned away from War.

If that happy time, foretold by Isaiah, ever comes when "nation shall not lift up the sword against nation; neither shall they learn war any more," will nitrogen, like Othello, be out of an occupation? Not at all. We shall still need explosives for excavation work, for clearing land of rocks and stumps, and for many other uses; and there is the whole field of industry and of medicine in which nitrogen can find use, as well as in the field of agriculture.

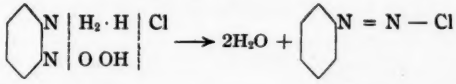
We read in the Scriptures that Samson, after a hirsute and militant career, had his hair cut and went to work for the Philistines as a corn grinder. Wars being now over, why should not our chemical Samson grind for us? We can set him to work directly and as a beginning have him turn out a few dyes.

When benzene is treated with nitric acid and the product reduced with hydrogen we get aniline. The equations follow.

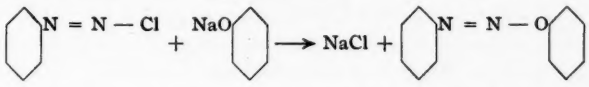


If now the aniline be dissolved in hydrochloric acid and treated with

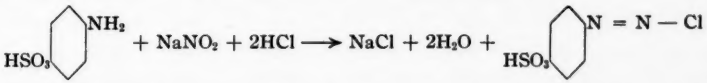
nitrous acid we get benzene diazonium chloride. Notice how nicely water splits off in the following equation:



If the diazonium compound be coupled with some aromatic compound a dye containing the chromophore —N = N— results. Here is some diazotized aniline which I pour into an alkaline solution of phenol. You see the dye which forms. It has the formula



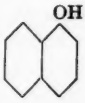
Here is a solution of sodium sulfanilate which I will diazotize with sodium nitrite and hydrochloric acid. The equation is

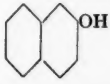


If the diazo solution be now coupled with a solution of beta naphthol a dye called Orange II results. In all these cases the part played by nitrogen is in the diazotization with nitrous acid, HNO_2.

It is of interest to note that the materials used in making some of the dyestuffs are also used in the manufacture of explosives. Aniline and phenol, for example, are so used.

Here are some pieces of cotton cloth which have been boiled in a solution of a dye called Primuline. I now rinse them in this cold water and immerse them in this very cold bath of sodium nitrite to which I add some hydrochloric acid. Do you notice any change in color? This is due to the formation of the diazonium compound. I remove one of the cloths and suspend it in a solution of alpha naphthol and you will see the developed color appearing on the cloth. I immerse the other in a bath of beta naphthol and you see a different result. Note that the difference is due to the differing positions of the OH in the two naphthols; in the alpha it is in position one and in the beta it is in position two. The diagrams will make this plain.





Picric acid is a dye as well as an explosive. Here is some wool dyed with picric acid. Picric acid is also an antiseptic. We can imagine a soldier marching to battle beneath a flag dyed with picric acid, to fall wounded

by a fragment of a shell exploded with picric acid and having his wounds dressed with picric acid at the field hospital. Nitrogen plays a triple role in this case. In common with many other causes, medicine makes its demands upon nitrogen.

Collodion, sold under the name of "New Skin" is a nitrated cotton dissolved in alcohol and ether. Acetanilide, used in headache powders, is a nitrogen compound; a little of it stops the headache but too much sends you where headaches are unknown. Nitrous oxide makes you unconscious while a minor operation is performed.

Cocaine, which makes you insensible to the pain of having a tooth pulled but does not make you insensible to the pain of paying for having it done, is a nitrogen compound. Quinine and many other drugs contain nitrogen. Nicotine, subject of Barrie's delightful essay "My Lady Nicotine," contains nitrogen. Opium, which gave De Quincy the magnificent dreams described in "Suspiria de Profundis," and its derivatives morphine and codeine are nitrogen compounds. Here is amyl nitrite, which causes the blood to flow to one's head when its fumes are inhaled. A good smell of this will cause the most hardened sinner to blush. Try a little, good sir. Even the drug fiend, you see, worships at the shrine of nitrogen.

Let us turn to the field of agriculture. The farmer requires combined nitrogen to maintain the fertility of the soil. Sodium nitrate, ammonium salts, and cyanamide are important as furnishers of nitrogen to the growing plants. Nitrogen from air is converted into oxides by the Birkeland-Eyde process of passing air through a flaming electric arc and dissolving the products in water to form nitric acid; this acid is then brought into contact with limestone so that calcium nitrate results and this is sold under the name lime-nitrogen as fertilizer.

"There's vitamines in peas and beans,
And there are proteins too;
Its nitrogen, say thoughtful men,
From which the proteins grew."

Even the plants must have nitrogen in some form to live and thrive. Some of the substances called indicators are nitrogen compounds. Here is a tall jar of water into which I will drop a little Congo red powder. You see the color as it falls through the water. I will just stir this up with a glass rod and we notice the change. On stirring more the color returns. Methyl orange is another indicator much used by chemists.

But we can't stop quite yet. Look at the list of industrial substances in which nitrogen plays a most important part. I have put on the board a copy of a chart which appeared in *The General Science Quarterly*, edited by W. G. Whitman, a graduate of Tufts. This chart illustrates the many ways in which combined nitrogen is of service to us all.

And now, nitrogen being responsible for so many things and having done

so much for us, don't you think it is time we sent nitrogen to school and taught it to spell? I will just touch this hot iron to the edge of this suspended filter paper and you will see what education can do for our element, this time in the combined form as potassium nitrate. See how slowly but accurately it spells out T—U—F—T—S. How would nitrogen do as a cheer leader at the football game?

But it is getting late. It is time to wind the clock, throw out the cat, and extinguish this Bunsen flame which I will do with a bottle of nitrogen, the element.

If I talk any longer you will think I have discovered perpetual motion, so I will close with the wish expressed on this sheet of white paper which I will immerse for a moment in a solution of ammonia in water.

THE DIRECT SYNTHESIS OF AMMONIA: A LECTURE TABLE EXPERIMENT

ALFRED T. LARSON, FIXED NITROGEN RESEARCH LABORATORY, UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

A number of requests have been made for an apparatus which will demonstrate the catalytic formation of ammonia from its elements and which at the same time can be employed either upon the lecture table or as a laboratory exercise in advanced inorganic chemistry. An apparatus suitable for such purposes is described in this note.

The essential features of the apparatus are shown in Fig. 1. A and B are flowmeters[1] by means of which hydrogen and nitrogen may be mixed in such proportions that the gases which enter the deoxidizer C will be approximately in the ratio of three volumes of hydrogen to one volume of nitrogen. The sketch indicates mercury or water-sealed traps placed in the gas supply line. When the gases are withdrawn from high pressure cylinders these traps facilitate the control of the gas flow and prevent "blowing" of the meters.

The deoxidizer consists of reduced granular copper oxide, maintained at a temperature of approximately 300–400°C. by means of the vapors of a high boiling liquid. The vapors of boiling diphenylamine have been successfully employed for this purpose. Boiling sulfur may also be used, although it produces a higher temperature than is necessary. As the gases leave the deoxidizer they pass through the driers, D and D′. D is filled with 6–10 mesh soda lime free from dust, while D′ contains fused potassium hydroxide. The purified gases then come in contact with the

[1] A discussion of details of construction and calibration of flowmeters is given by Benton, *Jour. Ind. Eng. Chem.*, **11**, 623 (1919).

ammonia catalyst contained in the tube E. This tube has a capacity of about 10 cc. and is shown with a preheating coil which need not be employed if the flow of gas is restricted to 100–200 cc. per minute. The ammonia catalyst is heated in the vapors of boiling sulfur. The entire apparatus is constructed of pyrex glass and all connections are welded. Mounted upon a suitable support, it may be made an attractive permanent piece of lecture table equipment.

The success of the ammonia synthesis depends upon the purity of the nitrogen and hydrogen gases, and the activity of the ammonia catalyst.

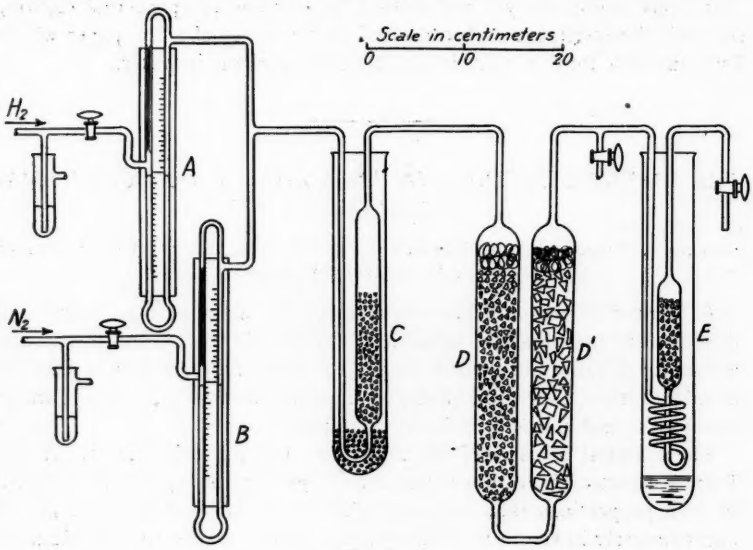


FIG. 1.

It is important, therefore, that the suggestions given below for the preparation of the purifying reagents and the catalysts be closely followed.

Preparation of the Deoxidizer

Any granular copper oxide, for example, such as is commonly used in organic analysis, makes a fairly satisfactory material from which to prepare the copper deoxidizer. A better material is made by precipitation, the method being practically the same as that described below for the manufacture of the ammonia catalyst.[2] The oxide is reduced in place by a stream of hydrogen at about 250–350° C. As water is one of the products of this reaction, the process should be completed before attaching the driers and the ammonia catalyst tube.

[2] Larson, Newton and Hawkins, *Chem. & Met. Eng.*, **26**, 495 (1922).

Preparation of Drying Agents

C. P. soda lime should be employed. Since this usually contains water purposely added in order to make it a better absorbent for gases such as carbon dioxide, it is advisable to give it a preliminary drying. This is readily accomplished by placing a tube of the material in a sulfur vapor bath and drawing dry air through it for about an hour.

A convenient method for handling fused potassium hydroxide consists in coating it on steel wool such as is sold for scouring kitchen ware. This is accomplished by dipping small rolls or balls of steel wool in the fused alkali contained in an iron dish or crucible. The operation is repeated until a fairly thick coating is obtained. The coated steel wool is cooled in a desiccator in which it is kept until needed. After use, the drying properties of this material may be restored by again dipping the steel wool in the fused hydroxide.

Preparation of the Catalyst

The catalyst is essentially a mass of porous iron which is made from an oxide of iron by reduction in a stream of hydrogen or of the mixture of nitrogen and hydrogen used in the synthesis.

A satisfactory oxide can be prepared as follows: 1000 grams of ferric nitrate (C. P.) are dissolved in 16 liters of water and allowed to stand for 24 hours. It is then warmed to 40° C. and poured slowly with constant stirring into 2.5 liters of 5.5% ammonia, which has also been warmed to 40° C. If the final mixture is not slightly alkaline, enough dilute ammonia is added to make it so. The precipitate is allowed to settle and is washed by decantation until the washings are practically free from ammonium nitrate. It is then transferred to a Büchner funnel and largely freed from water. The gelatinous mass is now placed in a mortar and kneaded until a very thin paste has been produced. This paste is transferred again to a Büchner funnel, and as much water as possible is removed by suction. The filter cake is broken into small lumps and placed in a drying oven, where it is dried for 24 hours at 70–80° C., and again for 24 hours at 120–130° C. It is then crushed and screened to 8–14 mesh. This preparation makes an excellent experiment for students in advanced inorganic chemistry.

The iron oxide is placed in the tube E and heated to the temperature of boiling sulfur. The mixture of nitrogen and hydrogen is then allowed to flow over the oxide. As reduction of the oxide nears completion, ammonia formation will begin. The amount of ammonia formed will slowly increase, finally reaching a maximum value which under favorable conditions will, of course, be the equilibrium amount possible at one atmosphere pressure and the temperature of boiling sulfur. This is about 0.25% ammonia. Half of this amount is easily obtainable and is sufficient for demonstration purposes.

Alternative Methods

Apparatus. Where only a temporary piece of equipment is desired, the ingenuity of the experimenter will suggest many modifications of the apparatus described. For instance, there may be substituted for the flowmeters any device which will furnish the nitrogen and hydrogen in approximately the ratio of 1:3. The drying units may be constructed from all glass wash bottles, or from calcium chloride jars. Split type electric furnaces are sometimes used in place of the vapor baths. The use of rubber connections should be avoided if possible. If rubber connections must be employed these should be as short as possible. All rubber parts should be heated for a time in dilute sodium hydroxide and then carefully dried.

The Catalyst. Some natural magnetites are sufficiently free from catalyst poisons such as sulfur and phosphorus to give satisfactory results when substituted for the precipitated iron oxide described. A satisfactory oxide may also be made by burning an iron rod in an oxy-hydrogen flame. The oxide drippings which collect during the cutting of iron with the oxy-acetylene or oxy-hydrogen torch are equally satisfactory and may be used if available. A sample of prepared catalyst sufficiently large for demonstration purposes will be furnished to any educational institution, if a request be sent to the Director of the Fixed Nitrogen Research Laboratory.

Sources of Hydrogen and Nitrogen. In some localities, hydrogen and nitrogen are most conveniently obtained compressed in cylinders. The usual laboratory methods for preparing these gases may be employed, however. When these methods are used, care must be taken that no gaseous poisons are introduced which are not removed by the purifying system described.

A convenient method for preparing a mixture of nitrogen and hydrogen in proper proportions consists in decomposing ammonia gas.[3] If pure ammonia gas be passed over a mass of iron catalyst heated to 450–550° C. the ammonia will be largely decomposed into its elements. If the residual ammonia be removed by "scrubbers"[4] and the remaining gases carefully dried, these will be present in just the right proportions for the synthesis operation. It is evident to anyone familiar with the ammonia reaction that this "cracking" process combined with the synthesis process offers an opportunity for discussing such features as exothermicity, equilibrium and volume change.

[3] Larson, Newton and Hawkins, *Chem. & Met. Eng.*, **26**, 493 (1922).

[4] Tall towers filled with beads or glass pearls, over which dilute sulfuric acid is allowed to trickle.

SOME NOVEL IDEAS IN GENERAL CHEMISTRY

WILLIAM FOSTER, PRINCETON UNIVERSITY, PRINCETON, N. J.

For a number of years the writer and his associates, in teaching general chemistry, have collected some of the most amusing of the statements made by their students. If one sat down and attempted to make up such "howlers" he would probably not be half so successful. What adds greatly to the delicious humor of most of these statements is the fact that the students who made them were, as a rule, in "dead earnest." Now and then, however, it is plainly to be seen that the student could not resist the temptation to be a humorist. The light contained in some of these "howlers" is really too good to be kept under a bushel. Those submitted herewith are given just as they were received—spelling included.

Theories and Laws

"A *chemical theory* is a statement that contains flaughs."

"*Van't Hoff's law* is termed the law of thermology."

"*Faraday's law* was discovered by an inventor who experimented a great deal with electricity in the latter part of the last century. He achieved the feat of laying the Atlantic cable."

"The *periodic law* says: 'By their atomic weights ye shall know them'."

"*Einstein's theory* explains the laws of constant and multiple proportions, as well as the law of combining weights."

"In a volume of 20 cc. we might have 1,000,000 molecules while in another 5,000,000; thus each of these would combine in different ratios if it was not for *Avogadro's law* which forbids unequal numbers of molecules."

Definitions

Valence is variously defined as "the number of hydrogen molecules a substance can hold;" "the apetite of an element;" "the number of hands an element has to hold hydrogen with," or "the number of hoocks an atom has to catch other substances with."

One student defines an *isomer* as "a unit of temperature measured by an *isometer*," while another says, "Isomers are bacteria that convert nitrogen into ammonia."

"An *electron* is a negatively charged particle with 1/2400 the mass of the hydrogen atom. But with speed the electron increases in mass and weight, so if the speed were infinitely increased the electron would be not only bigger than the earth and solar system, but even the universe. So this is why perpetual motion is impossible."

"The *sensibility of the analytical balance* relates to the amount of energy needed to destroy the balance of a solution."

"*Colloids* may be separated from crystalloids by filtering through a mucous membrane."

"Gas + fire + oxygen = a *Bunsen burner.*"

"*Oxidation* is the conversion of a metal or mineral into oxygen" is the idea of one student, but another holds that "oxidation is the power of crystallizing a compound."

"*Ammonia* is a medicine sometimes given to hysterical females."

"A bar of platinum oxidized at 0°C. = 1 meter."

"Aqueous tension is that which enables flies to walk on water."

"Absolute density of a gas is where it is under all the pressure it can stand."

"*Vapor density* is null when it comes to my chemical knowledge—if I may term it such," is frankly admitted by one freshman.

"*Phosphorus* is a flimsy substance found in the sea."

"White phosphorus is really an oxide of P,—P_2O_3. It occurs free in Tuscany, Italy, where it bubbles up from hot springs in water solution. It is a white, creamy-colored solid, soluble in water and is the anhydride of phosphorus acid."

"Bismuth and antimony are two important ores of arsenic."

"Arsenic is an amphibious element."

Descriptive and Miscellaneous

"*Sulphur* is pumped out of the ground by means of three pipes inside each other. There are three modifications: monoclinic, rhombic and iambic."

"The three forms of sulphur are aloclinic, amorphous and precipitous."

"The chief natural source of arsenic is onions and garlic."

"Ammonia was discovered by an Arab by the name of Jupiter Ammon."

"Nitrogen can be prepared by the electrolysis of air."

"*Chloral* (knock-out drops) is used as a hypnotic on account of its nauseating effect on the brain."

"Air is soluble in water at 2000° and then only slightly, tending to separate. The experiment proving this was performed in the laboratory."

"Lactic acid was also known to be actively optic."

"*Nickel,* like iron and cobalt, is attracted by a magnate."

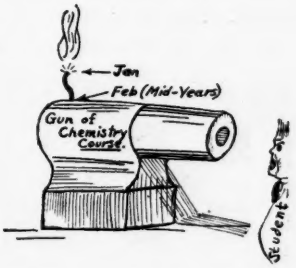
"When silica is fused with sodium carbonate, sodium silicate is formed. The commercial name for this is carborundum. It is a hard tough substance used in tools and other instruments requiring *hard ware.* If treated with hydrochloric acid it would form table salt, carbon dioxide, water and sand."

"When ozone is breathed in excess it causes traumatic disturbances of the pleural cavity."

"If you should eat 50 pounds of bacon which produces 100,000 Calories, you would be some warm baby when you got through." (There is no doubt about this.)

The following is an answer to the question, *Why has a solution of sodium sulphide an alkaline reaction?* "Why a solution of sodium sulphide has an alkaline reaction is one of the great problems of the Modern Chemist, for Lavoisier after 14 years of experiment in this field—it is not so much the heat—its the humidity."

Chemistry 104 as affected by the railroad strike.



Gun loaded with weighty formulas, active acids, oxides of heavy metals, and compressed paper!

All will recall the serious railway strike of a few years ago, when students so willingly volunteered to do what they could to break the strike. The accompanying reproduction of a drawing explains why one student did not feel prepared to take the test in chemistry. The second reproduction of a drawing made by a student at the end of a term, shows better than words his inability to pass the final examination.

EDITOR'S NOTE: While this is the first article of the kind to be submitted for publication, several inquiries have been received asking whether class-room humor would find a place in THIS JOURNAL. The final decision rests with our readers.

Casual inquiry has already revealed considerable difference of opinion. Some are in favor of devoting a page in every issue to "Moron Chemistry" or "Freshman Emanations," and have offered to contribute regularly, while others feel very strongly that to include such material would lower the dignity of THIS JOURNAL and impair its efficiency.

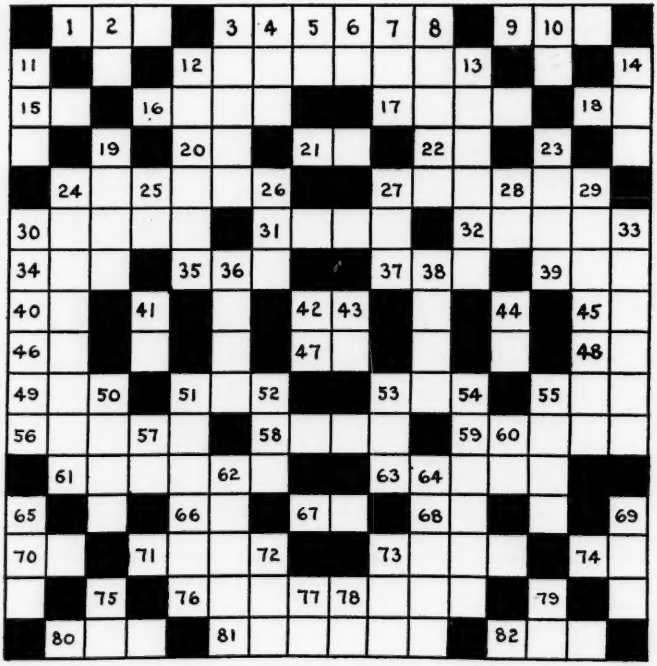
These facts are generally agreed upon: (1) Beginners in chemistry everywhere make almost countless mistakes—many of them genuinely funny. Undoubtedly most of them go undetected, but a few crop out at the stock-room window, on examination papers and in laboratory notebooks. This interesting collection of Dr. Foster's might have come from almost any laboratory of similar size. (2) Such items are not only interesting and refreshing but sometimes present a point of view which is of real value to the teacher. (3) Enough teachers have expressed a desire to contribute to insure well-selected material.

Do YOU favor starting such a page in THIS JOURNAL?

CROSS WORD PUZZLES IN HOLLYWOOD HIGH SCHOOL

RUTH C. VAN VLEET, HIGH SCHOOL, HOLLYWOOD, CALIF.

Cross word puzzles have invaded high-school chemistry. The first attack was stealthy, as solitary specimens slipped into class hidden between the pages of textbooks. Then they came more openly and in greater numbers, commanding the eager attention of the pupils before and between recitations. Arguments were frequent and the dictionary was thumbed as never before. New words and new definitions were learned eagerly.



What a waste of time and energy in looking up such things as: "A six letter word beginning and ending with 'k' and meaning a small Russian coin" or "The name of an African mammal consisting of five letters, the first two being 'o' and 'k'." If only this enthusiastic interest could be diverted to the study of chemistry. So in Hollywood High School a cash prize was offered for the best cross word puzzle using chemical terms, the only rule of the game being that puzzles submitted should not be shown to any member of a chemistry class. The puzzles are being placed on the blackboard with the accompanying key and credit is given for solving them.

Meanwhile the craze has laid siege to and conquered the History and Spanish departments and publishers are being consulted about printing the best examples from the various departments in loose leaf form so they could be circulated in this and other high schools. With an enrolment of more than five hundred in the Chemistry department, the blackboard method of presentation is too cumbersome.

So now, Japanese weapons and Australian plants have lost their former charm and pupils are just as eagerly pursuing the symbol for a metal used in electric filaments or the oxide found in sand or a six letter word which is the name of an allotropic non-metal. The puzzles are planned for beginning chemistry and must not be so difficult that they discourage further effort.

The accompanying example was submitted by a pupil who has not quite completed one semester of high-school chemistry.

KEY TO PUZZLE

HORIZONTAL

1. Part of a molecule.
3. An ore of lead.
9. The sulfide of an active metal. (sym.)
12. A group of atoms acting as units in chemical changes.
15. Bright gray metal recently discovered, belonging to group 3. (sym.)
16. A property of matter.
17. A spot produced in fruit by decay.
18. Brittle metal of a reddish gray color used for coloring glass. (sym.)
20. Prefix signifying down or away from.
21. Metal of a pale red color used for electrical purposes. (sym.)
22. Prefix signifying in front of.
24. A language.
27. A chemical used in fire extinguishers.
30. A pigment prepared from the ink of the cuttle-fish.
31. Wave-like molding.
32. A variety of corundum.
34. A pronoun contraction.
35. A small portion of land.
37. To obtain or learn.
39. Humor.
40. Look. (interjection)
42. Metal used as a coating for iron. (sym.)
44. Symbol of lightest element.
45. Symbol of element produced by radium emanation.
46. Symbol of rare element found in zinc blend and belonging to aluminium group.
47. Symbol of metal with reddish tinge forming low melting alloys.
48. Symbol of rare white metal used to alloy platinum.
49. A small metal vessel.
51. The top of a thing.
53. A short song.
55. How. (Latin)
56. A proper name. (Latin)
58. An age.
59. A covering for the foot. (Latin)
61. Produces heat.
63. To impede. (second person singular) (Archaic but still used in law)
66. A halogen gas. (sym.)
67. A very valuable noble metal found in Ural Mts. (sym.)
68. Symbol of metal belonging to sulfur group and found in gold and silver ores.
70. During. (prep.)
71. Substance formed from NaOH and fat.
73. Noun suffix. (equivalent to eer)
74. A light corrosive metal less active than sodium and more active than calcium. (sym.)
76. Used in fertilizers.
80. Sodium hydroxide.
81. A solution containing one gram atom of replaceable hydrogen per liter.
82. A metal in its natural state.

VERTICAL

2. Hydroxyl. (sym.)
3. One of the states of matter. (pl.)
4. Public notifications. (abbr.)
5. Symbol of the lightest metal.
6. Prefix signifying "out of."
7. To sieze suddenly.
8. A substance composed of two or more metals.
9. Symbol of element forming graphite.
10. Symbol of tri-valent element forming corundum.
11. Sulfide of mercury.
12. Pertaining to a radius.
13. Hidden or concealed.
14. The hydride of oxygen. (formula)
19. Sharp blows.
23. Over again.
24. To explode.
25. Metal of grayish white color used in small coins. (sym.)
26. After heating. (adj.)
27. A wooden pin.
28. A contraction of "them."
29. An arsenate of copper.
30. An oxide found in sand.
33. Oxide of Yttrium.
36. An oil obtained from roses.
38. The odic force of electricity.
41. A common useful metal with valence of two or three. (sym.)
42. Symbol of element used in type metal.
43. Symbol of metal forming twenty-five per cent of five-cent piece.
44. A non-inflammable gas. (sym.)
50. A number.
51. An allotropic non-metal.
52. To compensate.
53. An individual.
54. Salts of organic acids used in flavoring extracts.
55. United Literary Protective Association. (abbr.)
57. Symbol for rare gas existing in minute proportions in atmosphere.

60. A Hawaiian bird. Also a combining form from Greek word "egg."
62. A variety of alcohol.
64. Iron and carbon.
65. A metal used to protect iron.
69. Chemical term for salts.
72. Please turn over. (abbr.)
73. Suffix denoting occupation.
75. An ingredient of Prussian blue. (abbr. but not symbol)
77. Railroad.
78. Form of verb "to be."
79. A metal forming various colored compounds. (sym.)

OPEN MEETING OF THE CHEMISTRY CLUB OF LORAIN HIGH SCHOOL

A three-act play attempting to show some relations of the teaching of chemistry to everyday life.

ACT I. Chemistry Recitation Room

ACT II. Principal's Office

ACT III. Same as Act I

CAST OF CHARACTERS

Principal	Herbert Burton
Teacher	Keith Horn
Member Board of Education	George Hoffer
Pupils	Members of Junior Chem. Club
Parents of pupils	
Mr. Green	Wilford Moseley
Mrs. Green	Elizabeth Loose
Mrs. Brown	Zita Burke
Mrs. Smith	Trevabel Walper
Dr. H. N. Holmes, Head of Dept. of Chemistry, Oberlin College, and Member National Research Council	Paul Newsome
Dr. J. W. Ames, Chief Chemist, Ohio Agricultural Experiment Station	Elmer Brown
Dr. Hilton Ira Jones, Research Chemist, Redpath Lyceum Bureau	Joseph Justin
Dr. W. J. Hale, Chief Chemist, Dow Chemical Company	Heiman Brickman
Prof. Mary S. Rose, Dept. of Nutrition, Columbia University	Muriel Harper

Music between Acts

ACT ONE

Curtain rises, revealing a chemistry classroom with teacher's table and chairs arranged in order, the tables of the periodic law and atomic weights hang from the wall, the teacher is at his desk, distractedly shuffling books.

Teacher—"Now, let's see, the fifth period class has recitation. I do hope that they will be better than the last class. I simply can't solve the

problem, but plainly there is something the matter, either with our course or with the pupils. I wish there was a way of finding out."

(Teacher leaves room, gong sounds and pupils come in. Various remarks, most of them unfavorable, are heard. Teacher enters at opposite door. Confusion continues, but class comes to order quickly upon the call to order from the teacher.)

Teacher—"The class will now come to order. Hand in your problems."

(Expressions of dismay and gasps follow. Few papers are handed in.)

Teacher—"What, only these few papers! When I assign written work, I want all the class to do it. Why don't you have them, Harry? Were they so difficult?"

Harry—"Gee, I can't get them, when I don't even understand how to balance the equation right, can I?" (sarcastically)

Teacher—"This is the fifth day we have been working upon these equations. Well, I haven't time to explain them again, so come in after school. We will now recite on today's lesson. The first topic is 'Carbohydrates.' Emma, name some carbohydrates and give their formulas."

Emma—"Well, there's starch and sugar and some more, but I forget what they are."

Teacher—"Next, William."

William—"Sucrose, $C_{12}H_{22}O_{11}$; starch, $(C_6H_{10}O_5)_x$. That's all I know."

Teacher—"Well, that's not all. There are six more. (Teacher names them and gives their formulas.) They are very complicated but very important. Know them by tomorrow. Now here's something which you all ought to know. What is the formula for acetic acid, and a common substance in which it is present, Greta."

Greta—"I don't know."

Teacher—"Next." (No answer.)

Teacher—"Martha."

Martha—"The formula is $HC_2H_3O_2$, but I don't know the name."

Teacher—"Children, children, what is the matter? It is very important that you know especially the common names of these things. Acetic acid is the acid present in just plain vinegar."

Teacher—"What is an ester, Albert?"

Albert—"I don't know."

(Several asked and do not know.)

Teacher—"Does any one know what an ester is?"

Max (raising hand rather feebly)—"I think it is a salt of an organic acid."

Teacher—"Yes, when the hydrogen of the acid is replaced by a hydrocarbon radical, it is called an ester. Who can give an example?" (No response.)

Teacher—"I do not see how you have gotten anything out of today's lesson if you do not remember about esters."

Wilbur (volunteers)—"Stearin is an ester; its formula is $C_3H_5(C_{18}H_{35}O_2)_3$."

Teacher—"Yes, that is correct. Now we will recite on the chapter on soap, glycerine and explosives. Tell us about the composition of soap, Harvey."

Harvey—(No recitation.)

Sue—(Lame recitation on topic. McP. & H., p. 318.)

Teacher—"No, your equation was not right. Don't you remember our experiment last Thursday. What did we use, Judith?"

Judith—"I don't remember exactly, but I think it was stearin and sodium hydroxide."

Teacher—"You must remember our experiments. That was right. Now give the formulas."

Judith—"I can't answer."

Sam—"Stearin $C_3H_5(C_{18}H_{35}O_2)_3$ and sodium hydroxide NaOH."

Teacher—"Now what is formed?"

(After several unsuccessful attempts the teacher says glycerin and sodium stearate.)

Teacher (writing formulas on blackboard)—"Now we must balance this equation."

(Pupils with aid of teacher balance equation.)

Teacher—"Now it is right. This (pointing to board), $NaC_{18}H_{35}O_2$ is in plain language soap. Next topic, candles...."

(There follow poor recitations upon candles, glycerine and explosives.)

Teacher—"I don't see what is the matter with this class. You don't show any interest in your work. There will be no further assignment, and we will recite upon the same lesson tomorrow."

ACT TWO

Scene laid in Principal's Office. Principal seated at his desk; glances at his watch. Chemistry teacher comes into office.

Principal—"Good evening, Mr. Gilbert."

Teacher—"Good evening. I came to see you about a very important matter. It seems as if my chemistry classes simply can't get anything out of their study. All the classes today ended in a disgraceful failure, and what's more I find no explanation for it."

Principal—"H—m. We'll have to see about this. Possibly, we are using the wrong method of—"

(Knock at door. Irate father and mother enter.)

Principal—"Good evening, sir. Can I do anything for you?"

Father—"I came to speak about Harry Green's work in chemistry."

Principal—"That will be a pleasure. Allow me to introduce our chemistry teacher, Mr. Gilbert." (Greetings exchanged.)

Father—"You are the one we want to see, Mr. Gilbert. Harry is continually complaining about the chemistry course. He says it isn't so difficult, but he just has no interest in it, and before he started chemistry we couldn't keep him from experimenting."

Mother—"Yes, he says that all it is, is a bunch of dry formulas and equations, whatever that is."

Teacher—"Yes, I have noticed this, and it is indeed a grave question. Could it possibly be due to—"

(Knock at door, and member of board of education enters.)

Board Member—"Good evening. (Greetings exchanged, with introductions.) I came in to see you, Mr. Arnold, about a new chemistry book my son picked up recently in a neighboring city. You know, it looks good to me. I think it would make the work very interesting."

Teacher—"Interesting. H—m. How could it do that?"

Board Member—"Well, in the first place, it does what our present course does not, that is, it connects—"

(Knock at door; more parents enter. Greetings exchanged.)

Mrs. Smith—"Well, I came to see about Harvey's work, especially in chemistry."

Mrs. Brown—"Why, that is just what I came to see about. Is Harvey so disinterested also."

Mrs. Smith—"Why, the child just frets all evening about it."

Mrs. Brown—"Just like Greta. Why, I think it is just terrible how they make them learn and—"

Mrs. Smith—"Yes, it's awful. Course, I don't blame anyone in particular, but—" (looks toward chemistry teacher, who is examining book brought by member of board.)

Father—"Well, mother, I guess we don't know much about it. You see, Mr. Gilbert, I never could tell what chemistry was for anyway, but I sez to Mrs. Green we might as well let Harry take it. There isn't nothing to it, but I guess it won't hurt him."

Teacher (thoughtfully)—"Mr. Green, I think I know what is the matter. You say you do not understand what chemistry is for, as is also the case with many others. Parents, do your children ever connect what they learn in our course with their home life?"

Mrs. Brown—"Why, no. How can chemistry be connected with or be used in our lives?"

Teacher—"Just as I thought. It is the failure of our course to make chemistry real, to show its connection with everyday life that makes chemistry uninteresting."

Mr. Green—"But can chemistry be of use to us?"

Principal—"My friends, what we should know is what leading men in various walks of life think about chemistry and its relation to us and our everyday life. I wish that I might bring them one by one before you by merely shaking a magic wand."

(Here lights go out and spot light is turned on different characters, as they appear one by one.)

CHEMISTRY AND NATIONAL SAFETY.[1] *Paul Newsome.* I consider it the duty of every intelligent American citizen to have some knowledge of the intimate relation between our chemical resources and our national safety. There is no use in telling ourselves that there will never be any more wars. It is a fact that the better our preparation and the greater our economic independence, the less likely we are to become involved in future wars. We are remarkably fortunate in having unlimited natural resources of coal, petroleum, and iron. A country without these three fundamentals could not by itself last long in a modern war. Now that our navy is made up of oil-burning ships and our front lines are necessarily supported by auto-trucks using gasoline and the air overhead defended by airplanes using gasoline, we can readily understand that oil spells military power. We are producing today two-thirds of the world's oil. We lead the world in steel production. And yet, it is essential that we have such elements as tungsten, vanadium, manganese, etc., to use in making the alloy steels, which are now in demand. Fortunately, we have enough tungsten and enough manganese to supply our needs. As you will remember, high-speed shop work today demands tungsten-steel tools, which will stand up without loss of temper at high temperatures. We have plenty of copper, necessary for the brass shell cases and for all electrical apparatus. We have abundant cotton, which we treat with nitric acid in order to make gun-cotton, and from that smokeless powder.

But that raises the question as to our source of nitric acid. Every high explosive today requires the use of nitric acid at some stage in its manufacture. We used to make this by treating Chili saltpeter with sulfuric acid, and to some extent we do so yet. However, in time of war an enemy with a superior navy would cut off our importations of nitrate from Chili. In that event we should greatly develop the Haber process for making nitrogen and hydrogen unite to form ammonia. We plan to do this at Muscle Shoals. Our Chemical Warfare Service now has this process nearly ready for large-scale production. The difficulties are very great.

[1] Written by Dr. H. N. Holmes, Oberlin College, Oberlin, Ohio.

But when we get ammonia, how are we going to jump to nitric acid? That is a simple matter, for we can pass ammonia and air through a hot platinum gauze and a reaction takes place that produces nitric acid. That reminds us that platinum is one military essential not produced in any appreciable quantity in the United States. We are dependent upon Russia and Colombia for what we get. We are now obtaining large amounts of ammonia from our by-product coke ovens, such as you have in Lorain. And yet, before the war, the old bee-hive coke ovens wasted this ammonia. By catching all of these gaseous products from the distillation of soft coal, we are obtaining large quantities of benzol, which we can convert into picric acid, one of our high explosives. To do this requires the use of nitric acid. We are also obtaining from coal a great deal of toluol, which we can nitrate into T N T, another of our greatest explosives, and from the coal tar we make thousands of useful compounds, some of them invaluable medicines and others equally necessary aniline dyes. This coal tar industry was once almost altogether a German monopoly. Now we are competing with them, and, if a tariff on the organic chemicals made from coal tar is maintained due to your votes, we will always have an industry that overnight can stop making dyes, drugs, and fuels, and make the high explosives necessary in modern war. The very existence of such a convertible industry will always be a warning to aggressor nations that they had better leave us alone.

One of the foundation stones in all chemical manufacture is sulfuric acid. We used to import iron pyrites from Spain in order to make this acid. During the war we were forced to discontinue such importations and to develop the manufacture of sulfuric acid directly from Louisiana sulfur. We now, in times of peace, prefer to go on using this great deposit of sulfur in Louisiana and Texas. Again we are increasing our independence.

We have always been very dependent upon Germany for potassium salts, one of the vital parts of a complete fertilizer. We have, in the last few years, been obtaining some potassium salts from dried-up lakes in Nebraska and Nevada, and have learned how to obtain it from cement kiln dust and blast furnace dust. In time of need, where price is not such an object, we can supply our needs in this way. However, the Government Geologic Survey now believes that it has discovered a great bed of potassium salts in the staked plain region of Texas. Since we have the greatest phosphate rock deposits in the world, another essential in fertilizer, and since we now have methods of making ammonia and thus ammonium sulfate for fertilizers, it looks as if our agriculture will be independent of any possible blockade.

Finally, let me remind you that the United States has the only considerable deposit of helium in the world. Much of our natural gas, especially that in Texas and Kansas, contains nearly 1% of helium. This

rare gas is noninflammable, and hence will be used by this country to replace the dangerous hydrogen in filling our air-ships and balloons.

It took the highest type of chemical training to develop this independence and we chemists must convince the voters that a live chemical industry and a great body of efficient chemists will prove to be our best military weapon.

THE RELATION OF CHEMISTRY TO AGRICULTURE.[1] *Elmer Brown.* Chemistry is commonly considered to be an exact science. Agriculture is an art, a business, and an industry. It should be emphasized that agriculture is the greatest, the most necessary, and the most honored industry of civilization. The chemist was the first of the scientists to turn his attention to agriculture, and the results were so fundamental and practically important, and the science of chemistry capable of such broad application, that for a long time the great body of scientific knowledge concerning agriculture was known as agricultural chemistry. Later it was found necessary to include geology, physics, botany, biology, and other sciences, as most of the problems of agriculture are complex, and their solution requires the harmonious coöperation of several sciences.

Chemistry has performed a great part in all the industries which contribute to the prosperity, welfare, and happiness of mankind. Many of the essential industries are controlled in large measure by chemistry. Iron and aluminum, zinc and copper, silver and gold are extracted and refined by processes developed and controlled by chemistry. The preparation of many essential commodities is based on chemical analysis. Soap, paints, starch, sugar, paper, rubber products, dyes, and medicines are a few examples of the great number of products manufactured under chemical control.

The large and magnificent buildings in our cities and structural work everywhere would be impossible without the aid of chemistry, since most of the materials used have passed through the hands of the chemists. The cement, the tile, the glass, and the structural steel are all manufactured by chemical processes. The structural steel which is the skeleton of the modern skyscraper is essentially a chemical product, and requires chemical control through all the steps of its manufacture, from the reduction of the iron ore in the blast furnace, to the finished product from the Bessemer converter or the open hearth furnaces.

The development of the automobile which has become an essential means of transportation is largely due to chemistry, because alloy steel used in construction, the rubber tires, and the gasoline for fuel are made by processes under chemical control.

As improvement and progress in industrial processes are brought about by chemistry and other sciences, so progress in agriculture demands that

[1] Written by Dr. J. W. Ames, Chief Chemist, Ohio Agricultural Experiment Station, Woosly, Ohio.

to the greatest possible extent, practice shall be controlled by chemistry and every other science that deals with principles fundamental to agriculture. The subject of chemistry as applied to agriculture covers a wide scope and includes a study of scientific laws involved in plant and animal growth and production.

Chemistry has been of great service to agriculture in providing fertilizers which have, of course, a marked influence on crop production. In connection with other sciences, chemistry has performed an important part in the development of processes for obtaining nitrogen for fertilizing crops. There are the fixation of atmospheric nitrogen which involves various chemical processes and the recovery of nitrogen in the form of ammonium sulfate in the manufacture of coke from coal.

Another important service to agriculture in connection with fertilizers is the matter of fertilizer control, which functions in all the states, to prevent the buyer of fertilizers from being defrauded. Samples of fertilizers sold are analyzed by chemists, employed by various state departments of agriculture to determine if they contain the guaranteed content of nitrogen, phosphoric acid, and potash. Other great contributions of chemistry to agriculture and the public are the development of various fungicides that are necessary to combat the increasing number of diseases that attack fruits and vegetables and the production of insecticides to keep under control the hordes of insects that are ever ready to destroy fruits and other crops on the farm.

One could continue almost indefinitely in attempting to summarize all the contributions made by chemistry to agriculture and other industries, but this brief review will no doubt be sufficient to bring your attention to the great service chemistry, in conjunction with other sciences, has rendered to us all.

THE RELATION OF CHEMISTRY TO MEDICINE.[1] *Joseph Justin.* How far science has gone in helping medicine is shown if we remember that the alchemists considered the body made up of sulfur, mercury, antimony and bismuth. All disease they thought was caused by excess or insufficiency of these elements. Today antiseptics, introduced by Lord Lister have made serious infection unknown. During Civil War days, the amputation of a leg was considered fatal and 95% of appendicitis ended in death. Today amputations are rarely fatal and out of 39,000 operations for appendicitis, the Mayo Hospital in Rochester, Minnesota, lost only one. Our anesthetics have taken away the pain until as Saxe says:

"Patients in losing an arm or leg,
Don't suffer but rather enjoy it."

Vaccination has nearly eliminated small-pox, formerly ever present and

[1] Written by Dr. H. I. Jones, Research Chemist, Redpath Lyceum Bureau, Chicago, Ill.

over 90% fatal. Diphtheria the "black-death" of childhood has been nearly mastered and Schick inoculation promises to remove it entirely. During the Spanish-American War we lost more men from typhoid than from Spanish bullets, while in the last war, out of 2,000,000 soldiers only two typhoid cases developed and one of these was uncertain. The discovery of the many antitoxins for the cure and prevention of disease is a modern miracle. The French with the world's best engineers, with great experience fresh from the triumph of the Suez Canal, backed by practically unlimited capital, tried to build the Panama Canal and failed, for science had not yet mastered yellow fever and mosquito control. They did build the Panama Railroad and it is said to have cost 100 lives per mile. Today, thanks to science as applied to medicine and sanitation, the Canal Zone is the world's most healthful spot, with a lower death and disease rate than any other equal area on the globe. Hook-worm, the scourge of the south seas, has been studied and its prevention and cure made certain. Hay fever has been similarly mastered and even that most dreaded disease, the sleeping sickness, has been forced to yield up its secrets and at last a certain specific has been found. Thanks to the wonderful work of the Rockefeller Institute, thanks too, to this work of private philanthropy, Dakin's solution saved the lives of thousands of boys "over there." And Mr. Carrel's treatment for burns has saved other thousands. Burns that would ordinarily be 100% fatal are now cured with a certainty almost as great.

In the field of ductless gland medicine, however, the most spectacular victories have been won. Adrenalin which has proven a specific for Addison's disease and even brought the dead to life; thyrodectin that has saved so many with exophthalmic goiter; thyroxin that has conquered cretanism; insulin, pituitrin, and all the rest—what an immeasurable progress has been made. And we are only in its infancy.

Specific drugs to replace the old unscientific rule-of-thumb remedies, began with salvarsan. Luminal, the specific for epilepsy, soon followed. It does not cure this disease, to be sure, but it does prevent it for indefinite periods and it seems to have no bad effect. The recent advent of cinchocin, the specific for rheumatism, marks another such triumph.

Nature, to be sure, has supplied us with several specifics, notably quinine for malaria, and cocaine. But both of these have been found to be imperfect and the synthetic neo-quinine has proven to be nearly a specific for both flu and pneumonia. Cocaine was dangerous, the particular organic radicals causing the danger were identified and thus novocaine was the result—a drug more powerful than that produced in nature and without its attendant dangers.

So the fight of science in medicine against disease has gone on until the day seems near when medicine will no longer be a "practice" as unscientific

as an old woman with her bag of herbs, but shall become a real science, as exact as chemistry itself and as refined as modern surgery.

PROTECTION FOR AMERICAN INDUSTRIES.[1] *Heiman Brickman.* Once upon a time, in the never-to-be-forgotten past, while a student in Germany, and when alcohol and water mingled in all proportions and in perfect peace, I sat in a German rathskeller with a well-known organic chemist, a good friend of mine and a professor in one of the German universities. During the evening, he gave expression to the following toast: "Hoch Deutschland ueber Alles; mehr Kraft den Demokraten der Vereinigten Statten." My professorial friend had a son in Tennessee and of this son he seemed most proud because of his Democratic political alliances. Naturally, I paid but little heed to the toast as politics in America meant nothing to me nor to any other American student in Germany.

Little did I realize as I sat there that this famous chemist comprehended so much more of the future of Germany and of America than we students of science ever dreamed. Not many years after my return to this country, I received from this same German professor a letter in which he made mention of the wonderful progress organic chemistry was making in his country. He frankly stated that if we chemists in America could only help in supplying the Germans with more crude coal tar and other organic products, we would contribute greatly to the upbuilding of organic chemistry in the world. Now, as I look back upon this episode, I wonder what particular type of mental blindness enthralled us all during those early days. For I differed little from the majority of English and American chemists.

When the great War was a thing of the past and we, who realized the importance of chemical development, had an opporunity to reflect on the situation in its entirety, I comprehended at last just why this German professor wanted the Democratic party in the United States to reign triumphant. He believed that this party would best aid the world's markets by keeping the tariff so low that other countries might buy our raw products, manufacture them into finished goods, and then sell them at a profit in America.

During the early days of the development of the United States, when we might appropriately have been classified as shepherds, miners, and tillers of the soil, a protective tariff need not have been a necessity. Today, however, when we are launched primarily as an industrial country, and the agriculturist himself is taking up scientific methods for conducting his factory—the farm—upon an efficiency basis, no such thing as free trade or low tariff can ever obtain again without wrecking our Ship of State.

If we can be assured of a protection against the "dumping" of foreign goods on our shores, thus prohibiting home manufacture, we have every reason to believe that a great impetus will be given to the manufacture of

[1] Written by W. J. Hale, Chief Chemist, Dow Chemical Company, Midland, Mich.

our farm products into finished goods, and thus one of the greatest sources of organic chemical raw materials—the farm products—will supply an infinite number of chemical industries at home.

CHEMISTRY AND NUTRITION.[1] *Muriel Harper.* I should like to say that a knowledge of chemistry is essential to the understanding of the fundamental principles of human nutrition. The consumption of sugar is on the increase. It now amounts to nearly 100 lbs. per capita per year. The fact that it is merely fuel and does not carry with it other compounds essential to life and health makes it a menace to good nutrition, unless the consumer understands that the quantity must be limited, lest other foods be crowded out of the diet.

Another important point is that valuable nutritive elements in food are often lost in cooking processes, for example, by adding soda in cooking vegetables, by overcooking, or by throwing away the juices of the vegetables in cooking water. This loss seems trivial to one who does not understand its chemical significance.

(After last speech, lights come on and everything is very quiet, until Mr. Green speaks.)

Mr. Green—"This has been a great revelation to me. I shall talk to my son and see what interest I can arouse in him."

Teacher—"And we shall try to make our chemistry course one of real worth. I shall start planning tonight, and may I, with the principal's permission invite you and the parents of all my students to see the success of our efforts at the end of the semester."

Principal—"I am heartily in accord with this idea and shall lend any help that I can. May the interest kindled here tonight bear much fruit."

CURTAIN

A PROFESSIONAL SCHOOL OF ENGINEERING. *Charles Wadsworth, 3rd. Chem. & Met. Eng.*, **32**, 8, 304 (Feb. 23, 1925).—This is an analysis of the curriculum and underlying philosophy of the 6 year course in chemical engineering at Columbia which is essentially a graduate course. The first three years resemble more nearly a course in liberal arts, which is precisely what is intended. In the first four years only 15 hours of chemistry are taken. The last 3 years represent the period of professional training. By means of diagrams and charts the author of the article brings out clearly the relative importance placed on each subject, and sums it up as follows:

"The course at Columbia needs no eulogy. No course that is given by men such as those we mentioned in this article can be anything but a strong course. It suffers from an overdose of physics, industrial chemistry and electrical engineering. It suffers from too great flexibility in the matter of options, which tends to encroach on the time available for key courses. But there is no course in the country that deserves more careful study than this one. It stands for the thesis that the teacher should be the unit of education rather than the course, and it is the foremost champion of chemical engineering as a professional course taken by mature students with some previous collegiate training.

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[1] Written by Dr. Mary S. Rose, Professor of Nutrition, Teachers College, Columbia University, New York City.

Chemical Digest

Abstracts

Chlorine for Colds. H. C. KREMERS. *Sch. Sci. Math.*, **25**, 287–91 (1925).—It is now a fairly well-established fact that chlorine acts as a very efficient prophylactic and subsequent infection is very much minimized. During the late war it was noticed that the soldiers on duty in the chlorine departments of the arsenals were very much less susceptible to colds than the workers in the departments where no chlorine was present. Thirteen of the largest producers of chlorine report that among their employees in the chlorine departments there was an entire lack of influenza or the cases were very slight. Similar reports are given for bromine. Col. Vedder of the Edgewood Arsenal by exhaustive research has established the most favorable concentrations of chlorin in treatments at 0.014–0.015 mg. per l. for one hour. The summary of his work is as follows:

Diseases	Number of cases	Cured %	Improved %	No change %
Acute bronchitis	241	80	19.5	0.5
Acute laryngitis	127	78	19	3.1
Coryza (colds)	388	74.2	23.5	2.3
Chronic bronchitis	47	72.3	25.5	2.1
Chronic laryngitis	2	100	....	...
Chronic rhinitis	106	31.1	38.6	30.2
Whooping cough	9	88.8	11.1	...
Influenza	11	81.8	18.1	...

Results at the Navy Dispensary at Washington were substantially the same. It is urged that chemistry teachers serve their communities by assisting in providing local chlorine chambers for treatments and keep out frauds that are now appearing for sale. H. R. SMITH

Certification of Teachers in Virginia. W. T. SANGER, Sec'y. State Board of Education. *Virginia J. Educ.*, **18**, 267–73 (1925).—Extracts from the 1925 Edition of Regulations Governing the Certification of Teachers in Va. The following certificates are designed for high-school teachers; (1) The Collegiate Professional Certificate, (2) The Collegiate Certificate, (3) The Special Certificate. Special certificates in science are granted to applicants who present for credit four session hours each in biology chemistry and physics. They are then entitled to teach all branches of science in H. S. When this condition is not met the applicant will be given the privilege of teaching those branches of science in which he has credit for 6 session hours. Whenever the science credits aggregate 12 session hours in any two sciences, the applicant will be given the right to teach, in addition, general science, or first year science. Methods of applying for certificates or for renewals and extensions are outlined, and instructions given for teachers from other states. B.

New Germicides ("Twelve Years' Hunt for a Germ-Killer"). E. E. SLOSSON. *Yale Alumni Weekly*, **34**, 770 (1925).—A near relative to phenol is resorcinol, a milder substance which some of us have used in the vain attempt to make two hairs grow on a head where none would grow before. Both of these compounds consist of a ring of six carbon atoms. Professor Treat B. Johnson of Yale has discovered a new way of attaching side chains composed of from one to any number of carbon links, and it was found that the power to destroy germs increased as the chain was lengthened until there were six carbon atoms in the chain, but fell off thereafter. So the most powerful germicide of this series is the sixth which is accordingly called "hexyl-resorcinol," though doubtless a name with less than six syllables will be selected for it before it is put on the market, otherwise people would be reluctant to call for it at the drug store.

Dr. Veader Leonard of Johns Hopkins who has been testing the antiseptic power of these compounds finds this compound is about fifty times as effective as our old carbolic acid. That is to say, it could be diluted with fifty times as much water and would still be as poisonous to the microbes without injuring the bodily tissues. It can be safely taken internally by the mouth, and since it passes out largely through the kidneys it

may be used to destroy the microbes and parasites of a tract of the body that has been hitherto difficult of access.

The member of the family with four carbon atoms in the side chain, known as "butyl-resorcinol," is about half as powerful, but may prove quite as useful for such purposes as gargles, tooth-paste and the treatment of skin wounds, for it is stable and has no disagreeable odor.

All these compounds and many others are being systematically prepared and their physiological effects investigated by a committee of the National Research Council. Such team work is likely to bring about much better results, quicker and more reliable than the haphazard efforts of isolated individuals. The ideal germicide is yet to be found and it is quite possible that in time something may be found, or rather made, to take the place of such metallic poisons as mercury and arsenic, which do kill the parasites of the body but not without danger to their host. SCIENCE SERVICE

Grouping Students for Work in the Chemical Laboratory. W. G. BOWERS. *Education*, **45**, 7, 429 (March, 1925).—This article was written on the strength of data compiled by the author over a period of fourteen years and includes his own observations during that time. An average of 20% of the students were working alone and 80% working in pairs. The grades representing the better half of those working in pairs averaged 89.4% while those of the better half of students working alone averaged 78.3%. The author concludes: (1) The average strong students are neither benefited nor injured by working in pairs. (2) The average weak students are benefited by working in pairs. (3) The average strong and weak students working together, the strong students are not injured by being paired with weak ones, but the weak ones are benefited by working with the strong ones. (4) Only the mechanical genius is handicapped by being paired with another student and it seems to make no difference whether the other student is strong or weak. W. R. WEIMER

An Introduction to Chemical Technology in the Chemistry Course. H. ZEITLER. *Z. Physik. Chem. Unterricht*, **37**, 132–3 (1924).—All students should become acquainted with the principles of chemical technology. From a pedagogical standpoint this introduction should be practical, although some features must of necessity receive theoretical treatment. Those industries within reach of the school will afford the best opportunities. They should be typical examples of chemical technology and should at the same time combine economic and cultural importance. Students should not only become acquainted with the wide applications of chemistry, but also have their attention directed to the production, distribution and utilization of energy and the disposal of by-products. When the subject cannot be handled inductively, members of the class should be assigned various phases of the problem for presentation. In this event the teacher should provide references to the literature and also any equipment which the student will need for demonstration. Slides, charts, specimens, etc., are very often gladly furnished by industrial concerns. Whenever possible, actual inspection trips should be made by the class, starting with some comparatively simple process such as water purification. Before the trip it is of utmost importance that a study should be made of the principle underlying the process. If the plant is so extensive that the student will not be able to see the whole operation at once, it is advisable to diagram the plant on a blackboard, showing the relation of the various parts, the flow of materials and the disposition of the by-products. Following the inspection trip a session should be devoted to a review of the above points and to answering questions which have arisen. Under proper leadership a study of chemical industries in this manner may be one of economics, history, citizenship, and sociology as well as of chemistry. BAKER

Experiment on Catalysis. Dr. E. MANNHEIMER, Darmstadt. *Z. Physik. Chem. Unterricht*, **37**, 264 (1924).—The catalysis of the decomposition of $KClO_3$ by means of MnO_2 may be studied as follows: Use a side-neck test tube tightly fitted with a one-hole stopper carrying a short piece of glass tubing. To the outer end of this is attached a short length of rubber tubing to which is attached a small homemade bulb. In the bulb is a small quantity of MnO_2. To the side-neck is attached an ordinary delivery tube for collecting the O_2 over water. While the connection between the tube and bulb is closed by means of a pinch cock, about 2 cc. of $KClO_3$ is heated just to the decomposition point. The tube is then allowed to cool until O_2 ceases to come over. MnO_2 is next allowed to fall into the $KClO_3$. The rate of decomposition is greatly increased and is accompanied by a very noticeable liberation of heat. Students should examine the MnO_2 after the experiment. It is first freed from KCl and dried; then it is strongly heated to drive off O_2, and finally tested with HCl. A fresh sample of MnO_2 is similarly tested with HCl.

It is possible to show the catalysis of the decomposition of H_2O_2 with the same appa-

ratus. In this case some platinized asbestos is hung on a small hook inside the tube and later dropped down into the H_2O_2. A blank is run with plain asbestos. The exothermic character of this reaction is also plainly noticed. B.

Experiment: The Approximate Evaluation of Explosion Pressures. Prof. O. OHMANN, Berlin-Pankow. *Z. Physik. Chem. Unterricht,* **37,** 256–60 (1924).—The explosive mixtures consisted of illuminating gas and air. The top part of a Kipp generator served as the explosion chamber, being inverted so the ring neck was at the bottom. The walls were so thick that there was no danger of breaking. (The tendency to crack was minimized by keeping the neck clean and comparatively dry.) The capacity of the "pipette" was about $1^1/_2$ liters and its weight about 1 kg. Both openings were fitted with stoppers, the one at the top serving only while the pipette was being filled with gas by displacement of air. The bottom cork fitted tightly and had a small hold in the center. As a preliminary experiment the pipette is filled with illuminating gas and then lighted at the top while both stoppers are out. The flame burns quietly for about 15 seconds and then darts downward and explodes the mixture of gas and air now in the bulb. When the experiment is repeated with the bottom cork in place, the time interval before the explosion is about 1 min. and the explosion much more violent.

To measure the force of the explosion a spring balance (capacity, 10 kg.) may be placed under the pipette, leaving a space of 1–2 mm. between the cork and the balance pan. The action is so swift that it is impossible to record the movement of the pointer with the naked eye. O. used a number of small sentinels of modelling clay, which he stuck on the dial to record the path of the pointer. With the cork in place the pressure was more than 2 kg.; without the cork it was less than $^1/_2$ kg. When the hole in the cork was increased to 8 mm. diameter, and the pipette adjusted to various heights above the balance pan the following results were obtained: when the distance between cork and pan was 8 cm. the force was less than 1 kg.; when the distance was 4 cm. the force was 2.5 kg. and when the cork rested directly on the pan the force was 6–7 kg.

The time interval between the first ignition at the top of the pipette and the final explosion, as well as the force of the latter varied with the nature of the gas used. When H_2 is employed the force exceeded 10 kg. B.

Education and Legislation. J. G. BEARD. *J. Amer. Pharm. Assoc.,* **14,** 132 (1925).—The writer points out the splendid opportunities for service to the profession lying within the domain of the section of Education and Legislation of the American Pharmaceutical Association.

The paper should be especially interesting to chemists, in that it illustrates some analogous possibilities for the newly formed Division on Education in American Chemical Society. JOHN C. KRANTZ, JR.

Need for teachers. Z. M. COOPER. *J. Amer. Pharm. Assoc.,* **14,** 137 (1925).—The need for teachers with the proper ability and educational qualifications has become drastic in pharmacy schools. The secretary of the American Conference of Pharmaceutical Faculties points out the necessity for the Conference Schools to train students to become teachers of pharmacy and its allied sciences.

Although the demand for well-trained men is appreciable in the sciences closely related to pharmacy; the demand for teachers of pharmacy far exceeds any other.

JOHN C. KRANTZ, JR.

Chemistry in the Service of Medicine.—Bulletin issued by The Committee to Extend the National Service of Harvard University, 1924.—This pamphlet of about 20 pages contains a foreword written by Dr. Slosson in his usual entertaining manner, in which he shows that the jibe that the "doctor puts medicines of which he knows little into a body of which he knows nothing" is no longer true, and contrasts the methods of modern medical science to the hit or miss methods of bygone days. The main part deals with some of the more important chemical discoveries which have been of special value to medicine, and the manner in which chemistry is improving on nature's drugs and medicines. The service of chemistry to medicine and defense against gas warfare in the world war are mentioned. D. C. L.

Preservatives in Food. (Editorial.) *Nature,* **115,** 217–8 (1925).—It is known that food preservatives containing boron as a constituent, when given steadily and persistently to animals, provoke renal inflammation. It is quite commonly agreed that they may produce irritation in the alimentary tract, and should not, therefore, be given to children, invalids, or the sick. The elimination of a single dose of boric acid requires 5 or 6 days. It appears that boric acid and its salts are used largely, in Great Britain, in cream, butter, liquid eggs, margarine and potted meats, and are dusted over imported ham and bacon, but are prohibited in milk. The prohibition of any preservative in milk has doubtless led to increased cleanliness; and it has also been associated with in-

creased pasteurization. The recent Departmental Committee has recommended that the use of boron preservatives be prohibited; and the Minister of Health has indicated his intention to draft regulations for this purpose. There are already indications that the proposed regulations will not meet with universal approval. Sir William Pope, of Cambridge University, for example, does not think that the evidence against boron preservatives is convincing. The Ministry of Health will no doubt proceed cautiously. It is thought that the use of chemical preservatives is undesirable; and that their restricted use will not lead to scarcer and more expensive food. It is pointed out that there may be improved methods of manufacture and transport, so as to obviate the need of any preservative save cold. It is also pointed out that we should consider the weaker members of society. This consideration is sufficient to justify the extension of the present regulations against preservatives along the line recommended by the Departmental Committee. It is urged that the advice of Solon to the Athenians should be followed: "Have the best laws that can be kept, not the best laws that can be made."

WILLIAM FOSTER

Historic Set of Weights. J. S. FONDA. *Hexagon*, **15**, 81–2 (Nov., 1924).—According to Principal Irvine a set of weights encased in mahogany had been reposing for many years in a corner of a balance room at St. Andrew's. "One day an unusually ambitious assistant examined them and found their specific gravity to be that of palladium, a result which seemed incredulous but which was found to be true. The college records were searched and an entry in an old record book (about 1834) stated that the effects of the deceased chemist, Thomas Thomson, were to be sold, and the treasurer asked permission to spend 40 pounds at the auction. A later entry showed the purchase of apparatus, including a set of weights in a mahogany box. These were the palladium weights found in the balance room. Wollaston, the discoverer of palladium, was a friend of both Thomson and Dalton and had urged the use of palladium weights for very accurate work. Thomson, who was working out his equivalent weights at that time, had advised Dalton to publish his theory and it is conjectured that he had obtained these weights from Wollaston. At Thomson's death no one realized the value of the weights, so they came under the auctioneer's hammer simply as a set of weights. Today they repose in the vaults of St. Andrew's as a most treasured relic." B.

Training the Chemist—A Critical Survey. W. A. NOYES, JR. *Chem. Bull.*, **12**, 67–8 (1925).—The lack of properly trained chemists is due to, first, the *scheme* of the training, second, the type of teacher too commonly found in our colleges and finally, the low and uncertain standards of a large number of our schools.

To meet the first the student must be allowed more initiative and be made to conform less to "course work." There should be original thinking even to the point of having the student differ from the instructor.

Poor teaching results not so much from low salaries as from the method of selecting and the absence of successful machinery for discharging incompetent teachers who stay by the job because it is the line of least resistance. Many institutions have a practice of faculty inbreeding which does not generally make for virile instruction.

As to standards, "The process of weeding out the intellectual unfits does not start seriously until the student has entered college and there is it often carried out in an arbitrary, inefficient manner." More objective standards are needed that they may be more uniformly applied throughout our system of colleges. To administer such would require higher standards for selecting instructors. B. CLIFFORD HENDRICKS

The Training of Chemists in the University of Minnesota. N. C. PERVIER. *Chem. Bull.*, **12**, 85–6 (1925).—An analysis of the 320 alumni who have been granted degrees in chemistry since 1897. 89.7% are engaged "in the direct application of chemistry toward specific ends." Of these, 29.2% are classed as chemists; 19.6% as teachers; 10.7% as chemical engineers; while 10.7% are in industrial research. According to the records, 4 degrees in Chemical Engineering were granted in 1897—the first anywhere. The first B.S. degree was granted in 1902; the first M.S. in 1906 and the first Ph.D. in 1912. Since these dates, up to and including 1924, there have been granted 235 B.S., 84 M.S., 52 Ch.E. and 31 Ph. degrees. B.

The General Final Examination in the Major Study; Report of Committee G. *Bull. of Am. Assoc. Univ. Prof.*, **10**, 609 (1924).—The following are pressing needs of the student bodies of American colleges: (1) "A sense of unity of knowledge" as well as a sense of its vastness. Voluntary study by students to get this sense of unity cannot be safely relied upon. (2) An improvement in the manner and method of study. There is apparent a lamentable lack of independence, of initiative and of grasp. The only method of learning in the consciousness of a large per cent of American college students is expressed "take a course in it." "Many have never read a book straight through."

(3) A sense of responsibility for subject matter after it has met the temporary requirements of a given course. "We have (in our colleges) no final day of judgment in which a man shows what he has become; and, in which, further, he can judge the college by what it has done for him intellectually." There is a need of some form of "genuine competition (which) will rouse any man who has any right to be in college at all."

To meet these needs "the most promising (plan) is the general or comprehensive examination at the end of the senior year on the entire major subject as a field of concentration.*****It supplies a motive for escaping the chief defects of our system and ascertains if they have been escaped."

"There are, at present, two outstanding systems for ***** securing the advantages of the general examination." One is a part of the scheme for giving special honors to students of superior ability. The other is the newer, less used plan of a general examination on the major subject.

The second plan is in use in but eight institutions. The main body of the report describes the administration of this plan in the Universities of Washington, Harvard and Princeton and in Bowdoin, Mount Holyoke and Reed (Oregon) Colleges.

"Except for the difficulty of the expense and the exactions of administering it, the system is all to the good, and is the most promising academic innovation in many a day.*****Where the system is most fully developed, it has proved a genuine test of mental ability, for no mere industry can secure high rank; to do well, the student must not only know a good deal, but must also see relations and reason about a mass of facts. *****It tests the effectiveness of the whole educational system of the college."

B. CLIFFORD HENDRICKS

Industrial Poisons. Lecture by Dr. E. V. HENDERSON, Prof. Pharmacology, U. of Toronto. Reported in *Can. Chem. Met.*, **9**, 67–8 (1925).—The greatest difficulty in regard to industrial poisons is their recognition. Poisoning arising in the following industries are described: candy, nickel, lead, benzol, turpentine, carbon tetrachloride, wood alcohol, artificial silk, fur dyeing and bichromate. 0.015 cc. benzol vapor in 1000 cc. air will cause acute poisoning and rapid death, while 20 parts per million would probably cause chronic poisoning. Within limits it is possible to foretell poisons from their chemical composition, although this is by no means easy.

"For instance, in the series formamide, acetamide and propionamide, etc., the toxicity decreased, the first two being marked convulsant poisons; while in the series, acetonitrile, propiononitrile, etc., the toxicity increased. The carbilamines are extremely toxic, the formula being CH_3NC which suggests that prussic acid may possess the formula HNC. The introduction of chlorine leads to an increase in toxicity and anesthetic strength; methane is hardly anesthetic; monochlormethane somewhat; methylene chloride more so; and chloroform a good anesthetic although with definite toxicity. Carbon tetrachloride is much more toxic. Nitromethane and all this series are toxic as are nitrobenzine and especially the dinitrobenzines which are extremely toxic, while nitrobenzoic acid is almost nontoxic. The high toxicity of tetraethyl lead would hardly have been suspected. In the quantities causing death it can hardly be either the ethyl or the lead, but the peculiar combination of these two." B.

The Training of Chemistry Teachers, Prospective and in Service. B. S. HOPKINS. *Sch. Sci. Math.*, **25**, 233–8 (1925).—The teacher is by far the most important factor in the teaching of chemistry, and his two outstanding qualifications should be: (1) a knowledge of and an interest in the subject matter. (2) Ability to impart both knowledge and interest to pupils.

The teacher of chemistry requires special training; as much so if not more so than the teacher of any other subject. Successful teachers usually owe their inspiration to their own training under an inspiring teacher. A year of general college chemistry is not sufficient preparation for teaching even in a high school. The average college graduate is very apt to reteach his college chemistry to the high-school pupils, making it quite technical and lacking contact with life. Aside from the informational value of the subject, the training in observation, thinking, and reasoning that is possible is second to no other subject.

While normal schools have the avowed purpose of training teachers yet only 15% of the higher institutions of the United States offer specific courses in the training of chemistry treachers. Colleges are primarily responsible for the training of teachers of chemistry, so they should provide courses specially designed for this purpose. The training in school is the smaller half of the teacher's preparation. That which the teacher gains for himself, under his own initiative in the hard school of experience is worth far more. Teachers may grow rapidly in this by (1) studying the needs and interests of the community; (2) reading the journals and periodicals pertaining to the subject; (3)

membership in discussion groups on method, The Central Association of Science and Mathematics Teachers, and the American Chemical Society.

At the conclusion of this address before the Chemistry Section of the Central Association the following resolutions were unanimously adopted:

WHEREAS, the teaching of chemistry is a highly specialized profession which is becoming more intricate because of the increasing complexity of the science of chemistry; and

WHEREAS, a successful teacher of chemistry requires both a definite knowledge of the science and a definite training in its pedagogy, and

WHEREAS, the universities and colleges are not now supplying graduates who know both the science and the pedagogy of chemistry, therefore be it

Resolved, by the Central Association of Science and Mathematics Teachers in annual session, that we urge strongly upon colleges and universities throughout the country the necessity of offering more adequate teachers' courses, the purpose of which will be to provide adequately trained teachers of chemistry. H. R. SMITH

Chemical Literature. H. E. HOWE. *Cornell Chemist*, **14**, 21 (Feb., 1925).—Science advancement is impossible without an adequate literature: The problem of publication of scientific literature is exceedingly complex, on account of the diverse interests involved. Material of permanent value should receive first consideration. One difficulty is that many authors do not know how to confine their articles to small space. Concise presentation is an art and is of advantage to the author in securing acceptance, as well as to the editor, publisher, and reader. The value of any article is increased by accurate and complete literature references to previous work.

H. discusses the organization and work of the publications of the American Chemical Society: *The Journal of the American Chemical Society, Chemical Abstracts, Industrial and Engineering Chemistry*, with the *News Edition, The Journal of Physical Chemistry*, the *Journal of Chemical Education*, the *Chemical Reviews*, and the series of scientific and technologic monographs. He also gives great credit to the A. C. S. News Service for stimulating popular interest in chemistry. B.

Fluorescein an Aid to Tracing Waters Underground. HERMAN STABBER, U. S. Geological Survey. *The Reclamation Record*, **12**, 3, 122 (March, 1921).—Fluorescein heads the list of chemicals and dyes used for tracing water underground. One part in 40,000,000 parts of water is visible to the naked eye, and one part in 10,000,000,000 can be detected when viewed in a specially prepared long glass tube. Mineral acids destroy the color, some soils have a tendency to adsorb it slightly, and some carbonate waters lower its visibility. By noting the time required for the dye to traverse the underground channels, the concentration of the dye, and the period of time during which it is visible, considerable information may be secured. Several experiments are described in the article. D. C. L.

Service the Needed Spirit of Modern Science Instruction. OTIS W. CALDWELL. *School Life*, **10**, 85–7 (Jan., 1925).—"The best education for young people of secondary school age should be best for them whether they go to college or not.....Those who go to modern colleges as those who do not are in great need of a sound general education touching upon the knowledge and arts which enter into current life.....

"It is probably true that more advancement has recently been made in science instruction than in most other secondary subjects. The public believes in science;..... in the kinds of science which yield benefits clearly and soon.....Great discoveries are now so frequent that we note them almost as the expected content of the daily press.

"The unprecedented growth of science has produced many new.....subjects, which were crowded into the secondary schools and at the same time the common aspects of science were crowded out. The secondary courses became summaries of collegiate courses." For illustration the author takes what he considers the best college text in Physiography. Comparing this with a secondary text in the same subject by the same author, he finds that most of the chapters are almost if not quite identical. The secondary text is simply an abbreviation of the college text.

"The point of view of general science is slowly finding its way into the other high-school sciences. There does not seem to be a need of any reduction in quantity of learning in any special science subject; indeed it seems likely that the quantity of learning is being considerably increased. Its nature is somewhat changed, and this change toward a more significant science instruction should be useful both in high school and in colleges, but most useful of all to citizens. Are the science men, the specialists, really willing to have their subjects changed for this larger usefulness?....."

In 1918, a British science commission published a very comprehensive report by a committee of which Sir J. J. Thompson was chairman. The recommendations of that report are in spirit and in many details closely like the United States report.....

In the Orient everywhere one goes he hears of movements to improve and increase science instruction. It is a world movement, the whole civilized world realizing that the achievements and method of thought of modern science must be possessed by those who would aspire to progress..

Science knowledge has grown and will grow so that undreamed control of forces and materials will be had. Can the race be trusted with controls without an accompanying sense of responsibility for the knowledge thus possessed? The proper use of science in modern life, not only the possibilities of its use, must be developed in our courses of science instruction for young citizens in a free country. Such a sense of social and moral obligations we dare not omit, else we shall have an increased speed and quantity of living without the restraining anchorage of social responsibility..

Science courses for all the people must help all the people to interpret science for service, not science for power. Service, not power to control, is the needed spirit of modern science instruction. D. C. LICHTENWALNER

Freedom of Teaching in Science. *Science*, **61**, 276–7 (1925).—The following is an extract of the report of Committee M submitted to the Association of University Professors at its recent meeting in Washington.

"……It is, we believe, a principle to be rigidly adhered to that the decision as to what is taught as true, or what should be presented as theory in science or in any other field of learning, should be determined not by a popular vote nor by the activities of minorities who are persuaded that certain doctrines are inconsistent with their beliefs, but by the teachers and investigators in their respective fields. It would be absurd for the laity to attempt to dictate to the teachers of medical science what should and what should not be taught as facts in colleges of medicine. Teachers and investigators may teach doctrines in one decade which are discarded in the next; nevertheless, there is no body of individuals more competent than they to decide what doctrines are right, and if mistakes have been made, as they are bound to be with the best of intentions, the teachers and investigators have proven themselves to be the first to discover and to rectify the errors without the assistance of uninformed outsiders. We are never absolutely certain as to what constitutes truth, but if there is any method of insuring that what is taught is true better than that of giving investigators and teachers the utmost freedom to discover and proclaim the truth as they see it, that method has never been discovered. If those who know most about a subject sometimes decide wrongly, matters are not likely to be mended by putting the decision into the hands of those who know less. ……Students have a right to know the pros and cons of controverted subjects in every field. Teachers should be free to present those subjects and to express their own position in regard to them. It is only the things that are not true which have anything to fear from freedom of discussion, and it is only by the maintenance of this freedom that we create conditions under which the truth will most rapidly prevail." B.

Rare Elements Found in Petroleum Ash.—The presence of some of the rarer elements in petroleum ash has been demonstrated in experiments now being conducted by chemists in the Department of the Interior. The spectroscope has revealed a strong lithium line, indicating the presence of a valuable element whose presence was not previously suspected. Nickel is also plentiful, as is vanadium; it is even thought possible that the ashes of petroleum cokes may be utilized as future sources of vanadium and nickel. SCIENCE SERVICE

Hafnium.—The "baby" among chemical elements, hafnium, atomic number 72 in the table of elements, has been found useful in the making of filaments for electric lights.

This element, very closely related to the metal zirconium and contained to the extent of 1 to 5% in the zirconium in commerce, was discovered by G. Hevesy and D. Coster in Copenhagen, who first detected it in the X-ray spectrum and then isolated it chemically.

Now J. A. M. van Liempt, of the physical chemical laboratory of Philips' Glowlamp Works, Ltd., Eindhoven, Holland, has found that a small amount of hafnium oxide mixed with the tungsten used for electric light filaments makes it possible to readily swage and draw the tungsten. Pure tungsten cannot be used for incandescent filaments because of distortion of the metal due to recrystallization that takes place after manufacture. SCIENCE SERVICE

Photographic Films Developed after Fixing.—Topsy-turvy methods of developing photographic films and plates, by which the process is carried out in daylight instead of a dark-room, and the film is placed in the fixing bath first and then in the developer, has been shown possible as the result of experiments made at the Wagner Free Institute of Science by Dr. Henry Leffman over a number of years. The plate or film is first placed in a dilute solution of sodium thiosulfate in a dark-room. Although it seems entirely transparent when brought out into daylight, it is placed in a special developer and the image appears.

In photography, the silver bromide is mixed with some substance such as gelatine that can be spread out in a thin layer on a glass or celluloid support. This forms the plate or film, and, when exposed in the camera to the image formed on it by the camera lens, the parts struck by the light are affected, while the others are not. No change is apparent if the film is then examined, but this invisible or latent image may be brought out by development, which changes the latent image into one of very minute particles of metallic silver. This process leaves the parts that were not reached by the light as unchanged silver bromide, so it is necessary to remove it by fixing. Sodium thiosulfate dissolves the silver bromide, but not the metallic silver, and the result is the familiar "negative," with dark areas corresponding to the lights of the original scene.

This being the case, it would seem that if the silver bromide were first dissolved away by fixing, the latent image, supposed to be due to a change in the molecule, would go with it, but Dr. Leffman has demonstrated that it persists in the gelatin itself. The ordinary developer cannot be used, but by means of a special one containing mercuric chloride or bromide, metallic mercury is deposited where the silver would have been if the plate had been treated in the usual manner, and the negative may be printed in the ordinary way.

SCIENCE SERVICE

Fundamental Concepts. An abstract of three lectures, delivered by Dr. PAUL R. HEYL, Physicist, U. S. Bureau of Standards, Jan. 6, 7 and 8, 1924, at Carnegie Institute of Technology, and reported in *The Crucible*, **9**, 27–31 (Feb., 1925).

The Eighteenth Century Ideas. The physical scientists of the eighteenth century were diligent discoverers in an unexplored field. The facts they established remain for the most part with us today; but the point of view has completely altered. The mental attitude of the eighteenth century scientist may be characterized as materialistic to a degree which is difficult to realize at the present time.

Most of us have been taught that the subject matter of physics is two-fold—matter and energy. That was the orthodox nineteenth century doctrine, but the attitude of the eighteenth century was different. The scientists of that day studied matter only. The concept of energy was not recognized. Forces of all kinds, gravitational, mechanical, electrical and magnetic were regarded as properties of matter. The concept of force was strictly subordinate, secondary and auxiliary to that of matter. Gravitation, in fact, continued to be thus regarded up to recent years, when Einstein suggested that it was not a property of matter at all, but a space property (of which more later); and electricity has now gone so far as to reverse its former relation, and to claim matter as merely an electrical phenomenon. The idea that all forces were to be regarded as properties of matter was supported by what was known as the doctrine of imponderables. The mechanical force exerted by moving bodies could be readily enough explained as a material property, arising from the inertia and impenetrability of the moving mass. Other forces, more obscure in their action, such as electrical attraction, were not to be so simply explained. To account for these forces the existence of various kinds of imponderable matter was assumed. These imponderables were believed to be kinds of matter as real as water or air, but of a density so small that it could not be measured. In this, there was nothing absurd to the eighteenth century. It was known that air had weight, but this fact had been ascertained not so very long before. Previous to the invention of the air pump it was supposed that air had no detectable weight, that it was an "imponderable." And so great a difference was found between the weight of air and that of the lightest known solid or liquid that it was natural to ask: "Why may not there be a class of bodies with a density as much less than air as air is lighter than cork?" Such an imponderable fluid was postulated to account for the phenomena of heat. It was called caloric. All bodies were believed to contain caloric soaked up in their pores as a sponge holds water. And just as a sponge, though apparently dry on the surface, may yield water on squeezing, it was supposed that cold bodies by squeezing, rubbing or hammering, had their capacity for holding caloric reduced and in consequence some of this imponderable fluid was brought to the surface where it might be recognized by the sense of touch. The phenomena of light were similarly accounted for by supposing light to be constituted of exceedingly minute particles of matter emitted from luminous bodies. It was recognized that such emission of particles must eventually result in a diminution in weight of the body emitting the light. Failure to detect this was taken merely as an indication of the inconceivable minuteness of the corpuscles. We consider it ultra-modern in these days to speak of stars dissolving into light. The principal difference, however, between the modern concept and that of the eighteenth century is in the philosophical point of view. The older concept was thoroughly materialistic; that of our day is the opposite. The phenomena of electricity were likewise explained by the assumption of an electric fluid, or rather, two fluids, soaked up in matter

just as caloric was supposed to be. An excess or deficiency of one or the other of these fluids disturbed the balance, and gave rise to the phenomena of electrification. A similar imponderable fluid or effluvium was supposed to be the cause of magnetic attraction. Writers of that period express wonder that this emanation from the magnet should be able to pass through a sheet of glass, or a board, and affect a compass needle on the other side. Such materialistic views made up the attitude of the eighteenth century toward the phenomena of nature. To this statement we must now hasten to make an exception. There was one of these forces, namely what was called the "vital" force, which stands in a class by itself. While all the other forces were regarded materialistically this one force could not be so regarded. They all looked at it with a sort of superstitious awe. This matter was perhaps of more interest to chemists than to physicists, though there was then not so sharp a line of distinction drawn between them as now. In organic compounds and living tissues there was thought to be some force acting which could not be reproduced in a laboratory. It was believed that it was under the influence of this vital force that a plant was able to synthesize its carbohydrates and water from their elements. This theory was overthrown when Wohler made the first synthesis of an organic substance, urea, which he obtained by heating ammonium cyanate. This, chronologically, occurred in the nineteenth century, in 1828, but scientifically the centuries overlap considerably. The doctrine of a vital force died hard. In fact, it did not die at all—it emigrated. When many other organic syntheses had been achieved, and it was finally recognized that organic chemistry was only a complicated kind of inorganic chemistry, the doctrine of vital force retreated before the advancing frontier of knowledge into the less known regions beyond, namely, into the biological sciences. Here the complexity of phenomena was (and still is) so great that among the shadows of the virgin forest the vital force could still find a retreat. There are vitalists and mechanists among the biologists today, the controversy rages violently. I cannot see anything in it but history repeating itself. In this we may see a second characteristic of the eighteenth century science: a tendency to relapse into the supernatural. Many of the scientific works of the time read more like religious homilies with illustrations from the physical sciences than treatises on natural philosophy. As a third characteristic of the century I think we may mention a failure to lay emphasis upon the quantitative aspect of phenomena where it might naturally be expected by modern scientists. An instance of this was the curious phlogiston theory of combustion, which held sway for nearly the whole of the century until disproved by the experiments of Lavoisier with his balance. On this theory combustion was believed to be due to a certain substance called phlogiston, contained in all combustible bodies, and which could not be isolated on account of its great tendency to combine with air. Sheltered by matter, it might remain inactive; but if the matter were heated to a certain point some of the phlogiston was forced out, and immediately combined with the air. The resulting heat forced out more phlogiston until the matter was completely calcined or burnt. The slightest quantitative consideration would have shown the inconsistency of this theory; but no emphasis seems to have been laid upon this point until Lavoisier's day.

The Nineteenth Century: The Century of Correlations.—Looking back over the nineteenth century, as it is beginning now to fall into perspective, the principal accomplishment of the century may be said to have been the correlation of the inheritance received from the eighteenth century. This, it will be remembered, consisted of a number of isolated and distinct concepts, matter, heat, light, electricity, magnetism, and forces of various kinds, all such forces (except the so-called vital force) being regarded as properties of matter of some kind, ponderable or imponderable. The nineteenth century reduced these concepts to two: matter, and a new concept, energy. This was a large task, and took the whole century. In fact, it overlapped at both ends, beginning with Lavoisier and Davy in the eighteenth century, and extending well into the twentieth century before Einstein showed the correlation between inertia and energy. A typical example of one of these correlations is the development of the theory of light. At the very beginning of the nineteenth century two kinds of invisible light were discovered, the ultra violet, or chemical rays, and the ultra red, or heat rays. For a time these were considered as three separate entities; but gradually they were shown to have the same properties, obeying the same laws of reflection, refraction and polarization, and the three concepts gradually became regarded as one, ether-waves differing only in wave length. The last piece of experimental evidence for this correlation was obtained as late as 1907, when it was shown experimentally that the speed of travel of the visible and the ultra rays was the same. Another correlation, of the first magnitude in importance, was that between heat and work. This was begun, chronologically, in the last few years of the eighteenth century, by Davy and Rumford, but its complete development did not

appear for nearly half a century. With this development two names are connected: those of Mayer and Joule. The result of this correlation was the introduction of a new concept, energy. This concept was built up out of the "imponderables" of the previous century, heat, light, electricity. This concept, from its fruitfulness and far-reaching consequences became equal to that of matter in importance, and it is to be noted that it is definitely immaterial in its nature. The establishment of this concept marks a definite tendency away from the materialism of the previous century. One of the corollaries of the doctrine of energy carries with it consequences of poetic grandeur. This is the principle of the dissipation of energy. According to this principle, the various forms of energy in the universe are continually suffering transformations from one form to another, but with a gradual accumulation in the form of heat, in which form all the energy of the universe is apparently destined to remain forever in a form unavailable for any practical use. The activity of the universe is thus doomed to end in stagnation. A way of escape from this conclusion was sought by a number of scientists (Maxwell, Arrhenius), but the first satisfactory solution came only with the twentieth century, when it was shown from considerations of statistical mechanics that the universe must be regarded as capable of indefinite self-perpetuation; that heat not only could, but actually did run up hill on a microscopic scale, and that it was only a question of time and probability for it to execute this miraculous feat on a scale of sensible size. Another correlation, of the first importance from an engineering standpoint, was that between electricity and magnetism, due to the experiments of Oersted and Faraday. With the correlation between electricity and light, shown by Maxwell, and experimentally demonstrated by Hertz, the scheme of correlations was almost complete. One important thing yet remained uncorrelated with any other physical fact, in spite of many and heroic attempts to bring this about: Gravitation, at the end of the century was just where Newton left it two hundred years before. The final correlation of gravitation with other phenomena was to be one of the principal contributions of the twentieth century to science. A second great accomplishment of the nineteenth century was the establishment of the atomic concept of matter on a firm foundation. This concept was not new; Newton and Boyle had held it, to mention only two of the greater names. With the atomic theory the name of Dalton is usually connected. What did he do to warrant this? He did something characteristic of the nineteenth century: he made the concept quantitative; he introduced the idea of definite weights for the atoms of different materials, and introduced on this atomic basis the laws of definite and of multiple proportions into chemistry. A further attempt at correlation was made by Prout early in the century, who suggested that the different atomic weights were all multiples of that of hydrogen. With the progress of exactitude in atomic weight determinations this was regarded as an untenable hypothesis; but the twentieth century has completely vindicated Prout. The nineteenth century may be said to have closed, scientifically speaking, with the year 1895, in which Roentgen discovered what he called "a new kind of light." With this discovery, followed quickly by that of radioactive bodies the crest of the oncoming wave broke upon us. In the ensuing turmoil we are still struggling for a foothold. Some Lodge (it must be confessed), among the number, are clutching desperately at straws; others of us, equally at a loss for a solid foothold, are swimming as best we can, awaiting the quieting of the sea, when a new and firmer footing will doubtless be found. For several years prior to 1895 a curious pessimism overspread the minds of physicists everywhere. It was widely believed that the great discoveries of physics had all been made, that the science of the future was to be a science of residuals, of farther decimal places, of second order effects. To this there was at least one honorable exception. Lodge, in his "Modern Views of Electricity," (1889) placed himself on record as a thorough optimist. He said: "The present is an epoch of astounding activity in physical science. Progress is a thing of months or weeks, almost of days. The long line of isolated ripples of past discoveries seems blending into a mighty wave, on the crest of which one begins to discern some oncoming magnificent generalization. The suspense is becoming feverish, at times almost painful. One feels like a boy who has long been strumming on the silent keyboard of a deserted organ into the chest of which an unseen power begins to blow a vivifying breath. Astonished, he now finds that the touch of a finger elicits a responsive note, and he hesitates, half delighted, half affrighted, lest he be deafened by the chords it would seem he can now summon forth almost at will." The general progress of the science of physics in the nineteenth century may be said to have been steadily away from the materialism of the eighteenth century. At the end, we find the two main concepts of physics, matter and energy, equally dividing the ground between materialism and its opposite.

The Century of Hope. Though the Twentieth Century is but one-fourth past, we

may notice three contributions of the first magnitude which it has already made to the science of physics: the electrical theory of matter (including the inertia of energy); the quantum theory; and the theory of relativity. The nineteenth century closed with rather vague ideas current as to the nature of electricity. While some regarded it as an independent entity of unknown nature, others supposed it to be a state or condition of the ether of space, and hence a form of energy, like light. In the closing years of the century our ideas regarding electricity began to trend rather definitely in a certain direction, namely, toward a correlation of electricity and matter. The first step toward this was taken when it was recognized that a moving body, when given an electric charge, acted as though its mass had been increased in consequence of this charge; that is, that an electric charge in motion possessed inertia. The question then arose: may not the whole mass of the body be thus explained; is not ordinary matter only an electrical phenomenon? There was the opposite possibility to consider: electricity might be only a state or condition of matter; but the early years of the twentieth century saw the triumph of the first idea. Matter became merely an electrical phenomenon. The atom of matter is now regarded as a minute planetary system, with a central positive nucleus, and a number of negative electrons circling round it. On this theory, due to Rutherford and Bohr, the nucleus of the atom is responsible for its mass-properties, and the number and arrangement of the circulating electrons for its chemical and physical properties. The accuracy with which this atomic model fits the facts is uncanny. This subordinating of the concept of matter to that of electricity is a long step away from the materialism of the eighteenth century. Another equally long step was taken when it was shown that matter and energy were closely akin. This doctrine, known by the name of the inertia of energy, was first announced by Einstein as a consequence of the principle of relativity, but he later showed that it was a hitherto unrecognized corollary to Maxwell's electromagnetic theory, than which there is nothing more classical. This theory states that energy, like matter, possesses inertia; that when a glowing body cools off, emitting light and heat, it actually loses mass in the process. This loss is very small, far too small to pick up experimentally on a laboratory scale; but in the case of bodies like our sun it may amount to a large figure. The energy radiated per second by the sun is enormous. Converted into its energy value it gives the rather surprising figure of two tons per second. But so super-enormous is the sun's total mass to start with that he is good for this expenditure for something like a thousand million years. In this identification of the material concept of matter with the immaterial concept of energy we have taken another long step away from the eighteenth century position. In the light of this correlation of matter and energy it is but natural that the quantum concept should have arisen, for if matter is atomic and only an aspect of energy, then energy should be atomic also. The quantum theory atomizes energy into indivisible units, and as a consequence explains discrepancies that had previously existed between theory and experiment. Great as are its successes in this line it cannot be regarded as the last word in the matter, for it is in contradiction with a considerable body of experimental fact which is still best explained by the classical theory. Perhaps the ultimate solution will be found in some broader concept of which the two opposing theories are special cases. The theory of relativity will be treated here only so far as it is concerned with still another important correlation, that of gravitation with other physical phenomena. At the beginning of the twentieth century gravitation was a great mystery. In spite of much experimenting and more theorizing, the phenomenon of gravitation stood apart, refusing to show any correlation to other phenomena. In the year 1900 our knowledge of gravitation was just where Newton had left it, two centuries before. It was left for Einstein to point out that which when once seen is never forgotten—the correlation of gravitation with inertia. But great as are the coördinating and correlating properties of the theory of relativity, it cannot be regarded as the last word in its line any more than can the quantum concept; for the theory of relativity begins to fail us when applied to rotating bodies. Here, as Eddington says, it stops explaining phenomena, and begins explaining them away. It is, however, a great step in advance, and much of it will remain permanently in the theory of physics even when it shall be supplanted, as it must be, by some broader and better concept. Where, then, has the progress of three centuries in physical science brought us? Of the many distinct concepts of the eighteenth century not one is left. The sole concept of modern physics, energy, was not known in the eighteenth century; and this concept is above all things immaterial. The theoretical structure of our science is left without material means of support. The twentieth century so far is a century of bewilderment. But it is young yet; may we not call it the Century of Hope? Who knows whither it will lead us?

Local Activities and Opportunities

New England Association of Chemistry Teachers. The ninety-second meeting of the N. E. A. C. T. held a joint meeting with the Brown Teachers Association at the Metcalf Chemical Laboratory, Brown University, Providence, Rhode Island.

Prof. R. H. Ballard and Mr. H. W. Rice, of Hobart College, gave a very interesting paper on "Ammonia as a Solvent." Prof. H. F. Davison, of Brown University, read a paper on "Safety First in Storing Chemicals." W. C. Johnson, University Research Fellow, demonstrated the "Elements of Glass Blowing."

Visits were made to various points of interest about the University. These visits were in charge of Dr. F. L. Simmons and Mr. H. B. Pray of the Department of Chemistry and included trips to the Chemical Laboratory, John Hay Library, John Carter Brown Library, Engineering Building and Faculty Club.

The Report of the Eighty-Ninth Meeting of the Association has been published and copy may be obtained by non-members for a small cost by writing John H. Card, Secretary, 40 Summer St., Holbrook, Mass.

National Home of Pharmaceutical Chemists. Already more than $400,000 has been secured in pledges and cash for the National Home of the Pharmaceutical Chemists. The Committee which is carrying forward the work and of which Dr. H. A. B. Dunning, of Baltimore, is chairman is now looking for the most favorable location for this home and the type of building which can be put up. The site is to be voted on by mail this fall. The successful city will be fortunate indeed, for it will become at once the national headquarters of chemists and chemical manufacturers and will be the scene of far-reaching scientific research work.

According to Dr. Dumming the building will be artistic, getting away from the usual straight-up-and-down lines of business establishments. It will be used for developing educational propaganda of a modern sort, will include a complete scientific library and will house several research laboratories where scientists can delve into pharmaceutical and chemical problems.

Southern California Section of the A. C. S. The California Section wishes to extend to the chemistry teachers of the United States and other countries their heartiest invitation for the National summer meeting August 3 to 8, in Los Angeles. This is a chance to combine business and pleasure. The program committee has realized this, and hence have planned to not bore you with heavy all-day meetings. The Excursion features of the week's program are unique. You are to be entertained from sea level to 6000 feet altitude. There will be special trains out of all large cities where the fare will be less than one-half the usual fare.

Iowa Association of Science Teachers. The Iowa Committee of Chemical Education which was formed to look out for the interest of the chemistry teachers of the Association have done a constructive piece of work in creating a bureau of information. To this bureau any teacher in the state may refer any problems connected with their teaching, with which they may wish help or information. It should be of especial assistance to the less experienced teachers. It is hoped that the questions of general interest together with their answers may find their place in the columns of THIS JOURNAL.

University of California. Dr. Gilbert N. Lewis, Dean of Chemistry at the University of California has been chosen for the year 1925–26 to give the Silliman lectures at Yale University.

Chemical Society of England. The Council of the Chemical Society of England have elected the following officers: Dr. A. W. Crossley, President; Dr. T. S. Price, Secretary; Dr. F. G. Donnan, Foreign Secretary.

The annual meeting was held on March 26 and an anniversary dinner was held in the evening.

University of Minnesota. Dr. L. M. Henderson who has been holding the position as Assistant professor of Physical Chemistry at the University of Minnesota has resigned to accept a position as research chemist with the Atlantic Refining Company of Philadelphia.

Equation of Coöperation. The Business Chemistry recently published the "Equation of Coöperation" as follows;

If two men work separately, the value of their work is

$$1 + 1 = 2$$

If they work against each other the value of their work will be

$$1 - 1 = 0$$

If they work together, the value of their work is

$$(1 + 1)^2 = 4.$$

Yale University. Dr. P. T. Walden who holds the position of professor of chemistry at Yale University has been appointed Dean of the freshman year at the University. This type of an organization is somewhat new in educational circles and is being watched with much interest.

Electrical Measuring Instruments. Teachers

interested in measuring instruments will want to send for bulletins Nos. 533 and 984 which have just been issued by Leeds & Northrup Co., Philadelphia, Pa.

West Allis High School. A most live Chemical Society has been formed under the leadership of M. J. W. Phillips, head of the chemistry department. You do not have to be in a chemistry class in order to join this new society. All that is required is interest and activity in chemistry. It already has thirty members and it is anticipated that this membership will be doubled in the near future. The main features of the Society thus far have been the programs. It is planned to have men of great prominence in the chemical field give talks before the Society. The Society meets once a week on Tuesday at 3.45.

The interest in chemistry is further demonstrated at West Allis by the great number of A. C. S. Prize Essays submitted—127. Some one is surely alive in West Allis.

Cornell University. At the last meeting of the Cornell Section of the A. C. S. a very interesting program was given on Optical Chemistry.

Reversal of Electrodes in Spectrum Analysis, L. F. Audrieth; Spectroscopic Identification of Fluorine, W. E. Snee; Microscopic Identification of Paper Fillers, K. P. Geohegan, reported by C. Gurchot; Microscopic Tests for the Acids of Cl, Br and I, C. W. Mason.

Mills College. The course in American Ideals or Civic Education, required for the Secondary School Certificate in California, has been offered this year interdepartmentally at Mills College. Prof. Gibbons and Associate Professor Graham of the Department of Chemistry have contributed two lectures dealing with public problems in the field of Chemistry and the conservation and development of the chemical resources of the United States.

Dr. R. E. Swain, Head of Chemistry Department, Leland Stanford, gave a most interesting lecture before a recent assembly of Mills College.

Chicago Association of Chemistry Teachers. At the February meeting of the Chicago Association of Chemistry Teachers in connection with the Chicago Section of the American Chemical Society the objectives in teaching first year chemistry was discussed by secondary-school teachers, college teachers and industrial chemists. There was unanimity in the opinion that such a course should be generally cultural and deal with the chemistry of daily life problems. There is no reason for different treatment of pupils notwithstanding that some will carry the study of formal chemistry further in some school, or take extended study at college, or undertake the profession of chemistry. It should afford thinking from data according to scientific method and develop appreciation of the values of the service of science.

Columbia University. Dr. H. C. Sherman head of the chemistry department of Columbia has completed a very extensive tour, under the auspices of Scientific Associations, through the western states where he spoke principally before crowded local sections of the A. C. S. on such subjects as "Vitamins in Life and Health" and "Enzymes from the Chemical Point of View."

Rochester Section of the A. C. S. Mr. Harry A. Carpenter, contributing editor of the Journal of Chemical Education for the Rochester Section has appointed the following committee to coöperate with the New York State Committee on Chemical Education (THIS JOURNAL, **2**, 221 (1925)): Dr. V. J. Chambers, University of Rochester, Rochester, N. Y.; Dr. H. T. Clarke, Eastman Kodak Company, Rochester, N. Y.; Mr. Herbert Comfort, Batavia, N. Y.; Mr. C. C Edgett, Genesee Wesleyan Seminary, Lima, N. Y.; Mrs. Jane English, East High School, Rochester, N. Y.; Mr. Ralph Helmkamp, University of Rochester, Rochester, N. Y.; Dr. J. E. Lansing, Geneva, N. Y.; Mr. L. G. Smith, West High School, Rochester, N. Y.

Gerry's Tests of High-School Chemistry. "These tests are designed to determine, as accurately as can be done in a comparatively short time, the relative accomplishments of students of general chemistry. They yield objective scores uninfluenced by the variable standards of teachers and make possible an accuracy, in comparing the work of individuals or of groups, greater than can be derived from literal or percentile descriptions awarded upon the judgment of a single teacher. These tests, by the very nature of their origin and construction, are not to be considered as indicators of what should be taught under ideal conditions. They do not intend to specify the things that should be especially emphasized. Rather their purpose is to give a comparative measure of the gross results of teaching the kind of chemistry that is being taught, on the average, in the present-day American secondary school. Furthermore, they make it possible for a teacher to compare his class with other classes as to the degree of mastery of some of the phases of chemistry commonly taught." These tests are printed by the Harvard University Press, Cambridge, Mass.

Rhode Island State College. Plans are now being made for the Second Annual Chemistry Exhibit and Contest at the Rhode Island State College, Kingston, for the week of May 4th. While the general scheme is similar to that of last year, there are several innovations proposed which promise to add considerable interest to the events of the week.

As for the exhibit it may be said that an attempt will be made this year to make the individual displays of a symbolic nature and arranged in as beautiful and artistic a manner as possible. Those manufacturers who care to enter exhibits and the college students taking chemistry courses who arrange exhibits, will be asked to build up their displays on this basis.

Prizes will be offered for the two best exhibits put on by students from each college class and it is quite possible that special prizes will be offered as well. The list of those companies and friends of the college offering prizes is now being compiled and will be announced later.

The Rhode Island Section of the American Chemical Society has accepted an invitation to hold its May meeting at the College on May 8th. and its members will not only have an opportunity to see the exhibit but will also be addressed by Mr. J. C. Hostetter, of the Corning Glass Works, on the "Properties of Optical Glass." Mr. Hostetter has had a wide experience during and since the war on the preparation and properties of such glass and a most interesting talk is anticipated.

On Saturday, May 9th, the day of the Interscholastic Field Meet at the College, there will be held the Second Annual Chemistry Contest for the high-school pupils of the state. It will be conducted along the same lines and practically under the same conditions as last year's competition. A definite announcement of the rules of the contest will be published shortly.

There has already been some degree of interest manifested by both high-school teachers and pupils and inquiries are beginning to come to the college in regard to the contest. One teacher has stated that he expects to give tests to his pupils in order to be able to choose those individuals who are best fitted to represent that school in the contest at the college. Another teacher has stated that some of his pupils are anxious to compete not only in the track events but also in the chemistry examination. That particular possibility was anticipated last year and will be again this year by having the chemistry test take place early in the morning and completed before the athletic events.

Some interesting results followed last year's contest, and a few that have come to the notice of the College are as follows: A student from one of the competing high schools became so interested in the subject of chemistry that he considers making it his life work. He also entered the Garvan prize essay contest in this state and carried off one of the prizes of that affair as well as one of those at the State College Chemistry contest. The students at one of the high schools formed a chemistry club within the year and have extended their study of chemistry and their interest in the subject by making several trips to industrial plants. Several citizens of Newport, whose high school won the trophy last year, expressed their satisfaction to the teacher of the team that their boys could win a contest of brains as well as brawn.

Chemical Treasures of the Forest. By Dr. L. E. Wise, Professor of Chemistry, N. Y. State College of Forestry, Syracuse. A bound reprint of seven articles by the author which appeared in successive issues of American Forests and Forest Life during 1923–4. Twenty-eight pages, 9 in. x 12 in., 38 illus., N. Y. State College of Forestry, 1924. Titles of the various chapters are (1) Wonder Burners of Wood. (2) Knights of the Paper Trail. (3) Spinners of Wood. (4) Twilight of the Natural Dyes. (5) Trees as Oil Producers. (6) Alcohol via the Wood Route. (7) Our Oldest Industry. Each article is in itself a chemical treasure, from the angle of both content and expression. They represent a most successful attempt to carry to the lay mind the scientific and technical side of forest products; for the man with chemical interest, they bring together and correlate forest products with industry in a thought-provoking way.

Dr. Wise begins with charring processes, contrasting the older and the newer methods in a very happy manner, stressing the matter of the distillates and therefore modern equipment. Next follows a chapter on Knights of the Paper Trail in which the author is at his best. The historical development is very appealing and the treatment is adequate. As we are deftly led through chapters dealing with artificial silk, dyes and oils from trees, alcohol and naval stores, we feel the satisfaction of having been personally conducted.

The dress of the work is in keeping with the standard set by the author. The illustrations are well-chosen, really modern, and are an outstanding feature.

The net result is very satisfying and will leave a deep impression especially in the non-technical mind for whom it was primarily written. The industrial methods cannot fail to appeal and, of course, every one is more impressed than ever with the majesty of the forest. The College of Forestry has seen the wisdom of collecting this series of papers under one cover and is distributing copies to the various school centers of the State as a part of its educational program.

C. C. SPENCER.

Fellowship Stipends. The following views are expressed by President Butler of Columbia University in his Annual (1924) report (page 37): "The holder of a fellowship is a young student, making his way at every sacrifice, and gaining on the lower steps of the academic ladder that experience and training which will one day enable him to mount well to the top. The annual stipend of a university fellowship was fixed at $500 by the Trustees of Columbia University when in 1872 they established the fellowships in letters and in science that were awarded annually for some years. This same amount was adopted by the Johns Hopkins University when it established twenty fellowships in 1876. As fellowships multiplied, both here and elsewhere, $500, or $500 plus the amount of tuition, was pretty generally accepted as an appropriate stipend. What was sufficient in 1872 and 1876 is not sufficient in 1924. Fellowships of this type should carry a stipend of $1500, or the Fellows should be supported by loan funds that would give them an available income of that amount.

Scholarship and scholars are slowly but steadily coming to their own, and there is no possible reason why either scholarship or scholars should be starved while those whose occupation is with far less valuable and far less important instruments of civilization, are deemed worthy of every comfort and luxury.

Science Teachers of Arizona. During the State Teachers' Association, the Science Teachers' Association of Arizona was called to order by the President, Sanford Sweet, at 10.30 on Saturday morning in the Science building of the Phoenix Union High School. The following officers were elected for the coming year: Ralph B. Dixon, President, Phoenix; E. C. Anton, Vice-President Mesa; Forrest Bredon, Secretary, Tempe.

The program consisted of a talk by Mr. Lloyd C. Elliott, head of the Science Department of the Phoenix Union High School, on "Directed Study and Tests as Used in the Phoenix High School," and a paper by Dr. Frank M. Life, head of the Physics Department, University of Arizona, and a member of the Royal Academy of arts, on "The Science Teacher's Opportunity." Following is a resumé of the talk by Mr. Lloyd C. Elliott.

"The Science Department of the Phoenix Union High School has changed from the 45-minute recitation period and 90-minute laboratory period to the 60-minute period for everything. Each class meets 60 minutes, five days a week, this year, whereas they met three times for 45 minutes and two times for 90 minutes last year. The shorter time is compensated for by better preparation for the laboratory, less loss of time at the start and finish, and writing up notes out of class. The present arrangement is very satisfactory.

The general idea now is to eliminate the so-called 'recitation' period and to replace it with laboratory, reading, demonstration and discussion and explanation. The student is drawn out, encouraged to express his own views and directed in getting correct views. Science lends itself very much to those methods for the laboratory is there to prove or disprove the ideas and theories.

The old method was to assign a lesson and then spend most of the time seeing whether the student mastered it. The present method places the emphasis on the students acquiring the correct information by the right methods.

When a topic is completed a 'written lesson' is held to test the information and ideas the pupil has gained. These are mimeographed sheets in which several of the modern methods of testing are used. These include the plus and minus (in which the statement is marked right or wrong), the completion test in which a word is omitted and must be written in by the student, and tests in which several statements are given and the student chooses the ones he thinks are correct. Problems are also used and a blank left for the answer." [An examination in Chemistry is inclosed.]

Georgetown University, Washington, D. C., has started a campaign for an initial endowment of $5,000,000 for the establishment of a chemical laboratory for the Arts and Science School and to contain a chemical-medical research plant. Eminent specialists in the various departments of chemistry, pathology, bacteriology, pharmacology and biochemistry with the assistance of associates and graduate students will find here ideal conditions to promote researches in methods of prolonging human life, preserving health, and preventing disease.

It is expected to have this laboratory in operation within four years. George L. Coyle, S. J., head of the Department of Chemistry, is on a two months' trip conferring with men who are supporting this movement.

Dr. E. W. Guernsey of the Fixed Nitrogen Laboratory, American University, will have charge of chemistry in the newly organized College of Liberal Arts of the American University located at Massachusetts and Nebraska Avenues, N. W., Washington, D. C.

At a recent meeting of the **Washington Chapter of the Society of Sigma Xi,** held at the Bureau of Standards, Mr. C. Francis Jenkins, well known Washington inventor, gave an illustrated talk on "Radio Transmission of Photographs, Photograms, and Moving Pictures."

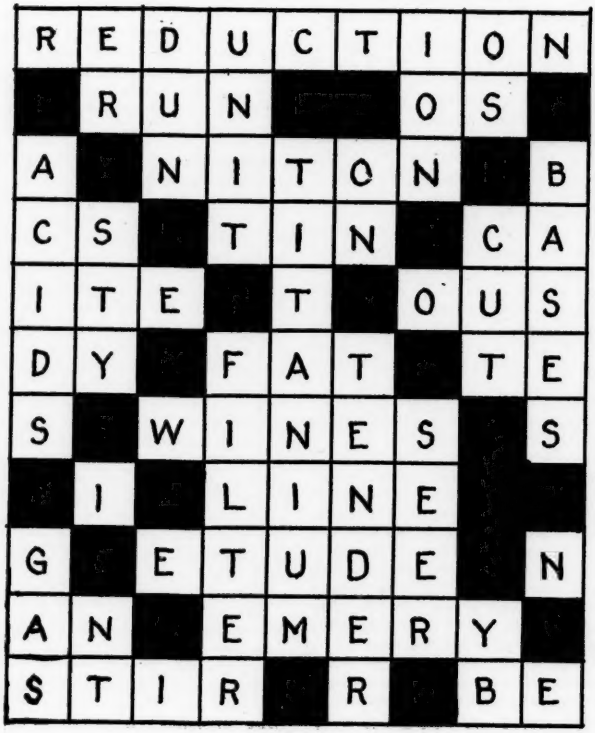
Applications for the **Grasselli Graduate Fellowship in Chemistry** at Oberlin College for 1925–26 should be made at once. This Fellowship carries a cash stipend of $500 with free tuition and fees, a total value of about $800. Candidates must have the A.B. degree, about four years of under graduate chemistry, a reading knowledge of French or German, and a year of college physics. Research may be elected under Prof. W. H. Chapin on beryllium or on thermal methods of analysis: under Prof. J. C. McCullough on metallography or on alloy structure: or under Prof. A. P. Lothrop on organic or physiologic problems. No work in colloid chemistry will be offered because of the absence of Prof. H. N. Holmes in Europe.

University of Nevada. The Robert L. Fulton lecture foundation recently established at the University of Nevada, for the purpose of obtaining prominent lecturers to speak before the student body and faculty is the means of bringing Dr. Robert A. Millikan to the University this year for a series of three lectures. He will take for his subjects "The Electron," "Light Waves," and "Stripping the Atom." The terms of the bequest establishing the foundation make provision for a group of lectures each year.

University of Virginia. Professor Hall Canter, Chairman of the Virginia Section of the American Chemical Society, and Professor of Chemistry at Randolph-Macon College, gave a talk entitled

"Research and the Public" to the graduate students at the University of Virginia on March 25th.

The Virginia Section of the American Chemical Society will meet at the University of Virginia, in place of Richmond, on April 17th.

The freshman class at the University of Virginia has this year established a semi-monthly Chemical Newspaper. Students present abstracts of articles of a chemical nature which appear in the daily papers or current magazines and receive credit for each abstract accepted.

Answer to March Cross Word Puzzle